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Topics of the Month

One hundred new sulphur projects

THE pessimistic pronouncements on sulphur supplies which were common a year or so back have now been replaced by optimistic assertions that the shortage is well and truly past and that the world can look forward to ever-increasing supplies of this important element. Such predictions are possibly more optimistic than they should be, even if they are understandable as a reaction to the extreme gloom generated during the height of the sulphur crisis. In the last analysis sulphur is an exhaustible commodity. It cannot be manufactured from renewable raw materials. Therefore it still behoves us to use it economically and it seems unwise to give the impression that a material which was desperately scarce in 1951 is suddenly super-abundant in 1952. Owing to a slackening in demand and an increase in production from all sources, there is indeed more sulphur available today, a fact reflected in the drop in price to about $26 per ton, compared with the fantastic quotations of $100 to $200 last year. Furthermore, according to Mr. L. M. Williams, president of the Freeport Sulphur Co., there are now about 100 sulphur projects afoot in the 'free world,' which will add more than 4,000,000 tons to world supplies by 1955. One-and-a-half million tons should be added by these projects during this year, 1,350,000 more next year, 250,000 in 1954 and 900,000 by the end of 1955.

Of this 4,000,000-odd tons, 2,448,000 will be supplied in the form of brimstone, either mined or from sour gas, refinery and smelter gases. The balance (1,592,700 tons) will come from pyrites, sulphate minerals (*e.g.* anhydrite), refinery and smelter gases. Most of the projects are in North America. However, it is interesting that there are new brimstone projects in Italy (100,000 tons p.a.), Japan (100,000 tons), Turkey (7,000 tons), Ecuador (25,000 tons) and Columbia (12,000 tons).

New sulphur and acid plants in Britain

NEW British sulphur projects consist of utilising refinery gases and anhydrite. Of the former projects, the only one now operating is at the Stanlow refinery of Shell, which is producing 10,000 tons p.a. At Shellhaven the same company is building an 8,000-ton plant which should be working next year and at Fawley the Esso Co. are building a 12,000-ton plant which should also come into operation in 1953. Total British refinery gas sulphur output will thus be 30,000 tons, a small but very useful addition to our supplies, not least because of the high purity of the product.

The anhydrite projects are three in number: I.C.I. at Billingham, which will provide an additional 25,000 tons p.a. of sulphur, United Sulphuric Acid Corporation at Merseyside (70,000 tons) and Solway Chemicals Ltd. at Whitehaven (23,000 tons). All should be working in 1954.

These six projects will provide additional sulphur. At

the same time some British sulphuric acid plants are being converted from brimstone to pyrites burning. What will be the future pattern of British sulphuric acid manufacture in terms of raw materials used, bearing in mind that in 1949 the Association of British Chemical Manufacturers estimated it to be: sulphur (imported brimstone) 47.4%, pyrites 21.5%, spent oxide 16.7%, zinc blende 8.5%, 'others' 5.9%. Mr. W. A. M. Edwards, of I.C.I., in a paper read before the Society of Chemical Industry last December, but only just published, estimates that in 1955 the U.K. will require 2,250,000 tons of acid. He expects that 20% of this will be made from anhydrite, 40% from pyrites, less than 25% from spent oxide and zinc blende, and between 15% and 20% from brimstone. To achieve this he thinks that a million new tons of capacity will have to be built. At the time he gave his paper 90% of this was in hand or planned. If these estimates prove correct, by 1955 just under 50% of Britain's sulphuric acid will be made from indigenous raw materials and smelter gases, compared with less than 30% in 1949. More important, perhaps, will be the lessening in our dependence upon brimstone, from nearly 50% to less than 20%. However, still more efforts must be made to exploit indigenous resources of sulphur, both for the sake of increasing world supplies and helping to balance Britain's trade accounts.

£47,000-worth of welding research

AN outstanding year in the growth of research facilities is recorded by the British Welding Research Association in their report for 1951-52. The new laboratory building has been completed. The special equipment—including the 100-ton Losenhausen fatigue testing machine—has been installed and is already in operation. With the support of the Department of Scientific and Industrial Research a special grant has been obtained from E.C.A. funds for the purchase of a Kentron hardness testing machine which is being used in the metallurgical laboratories. Complete *Aircomatic* welding equipment has been obtained on loan from the Ministry of Supply, also for use in the metallurgical laboratories, and a 50-ton Denison tensile testing machine has been added to the equipment of the new fatigue testing laboratory.

During the year over £47,000 was spent on actual welding research within and outside the Association's laboratories. This work is carried out through a number of committees and covers a wide range of investigations. For instance, the work of the Light Alloys (Metallurgical) Committees has been concentrated on the development of welding processes employing gas-shielded consumable bare electrodes, *i.e.* the self-adjusting arc and controlled-arc processes, and in a number of cases equipment has been constructed in the Association's laboratories. The American *Aircomatic* equipment employing the self-adjusting arc process has been used for investigations on welding techniques and the metallurgical characteristics of welds.

There are several engineering committees dealing principally with fatigue and structural problems and some are studying welded pressure vessels. Stress measurements have been made under various conditions and experiments have been carried out with the 'stress-probing' technique for obtaining rapid stress surveys. Investigations into the behaviour of welded joints in pressure pipelines under fatigue loading are aimed at evaluating the fatigue strength of pipe butt welds and the reduction of strength caused by weld faults. The latter aspect is related to the radiographic examination of pipe butt welds, and the possibility of correlating fatigue and radiographic results will be investigated to provide guidance on acceptable weld standards.

The resistance welding section of the Association has been engaged on the completion of the analysis of data on spot welding of certain aluminium alloys of the *Duralumin* type; on the spot welding of mild steel, and multi-projection welding of mild steel. Progress has been made with the design and construction of a simple and robust workshop instrument to record current and load simultaneously on a time base. Investigations into fundamental aspects of spot welding have been commenced.

This note can give only a brief impression of the many activities of the Association, which is financed jointly by the D.S.I.R. and industry.

Dearth of chemical engineers in the U.S.

SEVERAL large U.S. companies have recently spent thousands of dollars on radio and magazine publicity in attempts to glamorise the chemical and engineering professions in order to attract more men into them. The U.S. chemical industry has been unable to get anywhere near as many graduates in science and engineering as it wants. It now employs about 100,000 chemists, 30,000 chemical engineers and 17,000 physicists, and this pool is not being replenished fast enough. In 1950 10,600 B.Sc.s in chemistry were awarded, but preliminary estimates indicate that only 6,800 will be awarded this year, and only about 5,600 in 1953. The need for chemical engineers alone is indicated by the fact that the chemical industry could have used 5,000 of them last June, but only 3,800 graduated, of whom 1,000 were claimed for military service.

Present U.S. production of industrial chemicals is 550% more than it was during 1935-39, and the industry will have spent more than $600,000,000 on new expansions between 1950 and 1955. The demand and openings for prospective graduates will thus be even greater in the next few years.

In an analysis of the scientific manpower shortage in the U.S., J. W. Neckers, writing in *Chemical and Engineering News*, blames the situation on the current educational system. The policy of education for all—a commendable one—has been carried out at the cost of having large classes with, consequently, a shortage of equipment and facilities. Further, the primary objective today is training for citizenship, and in many instances the bad are taken with the good and all made to feel necessary and important. Discipline of either a physical or mental nature must be minimised, with the result that mathematics, grammar and the sciences—the mental discipline type of courses—have given way to the less rigorous subjects that are used to create 'attitudes' and 'social adjustments' for students at all levels of intelligence. Schools are urged to use all kinds of tests and techniques to help the backward child, which is as it should be, but a corresponding programme for the development of the more brilliant students is lacking in many cases. Science subjects are the most difficult ones in the curriculum and, therefore, they attract the superior student. But if this superiority is neglected and mediocrity is encouraged and accepted, from where will come the future scientists?

Another reason is that many chemistry teachers have left the profession and obtained higher-paying positions as chemists in industry, with the result that their place has been taken by persons with possibly just a year in college

chemistry. Such teachers often have their major interests elsewhere and this fact must influence the guidance on careers which they give to their students.

Many of these obstacles to an increased supply of science graduates, and hence of chemical engineers and chemists, exist in Britain. There is the same shortage of good science teachers for the same reason that pay is lower than in industry. Also, there is the same tendency towards levelling down educational standards. For example, the scheme for the abolition of distinctions and credits in the new General Certificate of Education cannot but lessen incentive and encourage mediocrity. However, when it comes to industry's attitude towards science graduates the similarity between the two countries ends. The Americans are far more anxious to employ science graduates and offer them high salaries and seemingly endless opportunities for advancement.

Czech chemical industry's failings

RELIABLE facts and figures about the Czechoslovak chemical industry—before the war the most important east of Germany—have been unobtainable in recent years. As in other Iron Curtain countries, the chemical industry has been given a leading role in the effort to use indigenous raw materials to replace supplies formerly obtained from the West and its manufacturing programme has been adapted to the needs of Russia. With the exception of occasional reports stating that the production of certain basic products has been expanded and the manufacture of some of the newer pharmaceuticals started, news about the Czechoslovak chemical industry has been confined to the usual percentage figures, claiming 'overfulfilment' of the current national plan, which have become such a dreary and generally meaningless feature of all the economic news from countries behind the Iron Curtain.

More recently a better idea of conditions in the industry has been given by an 'analysis of the situation in the chemical industry' by the Presidium of the Central Committee of the Communist Party of Czechoslovakia, a procedure which, according to Russian precedents, is normally followed when there is need for serious criticism.

It appears that the industry succeeded during the last few years in increasing the output of certain chemicals, *e.g.* coal tar dyes, some pharmaceuticals and potassium hydroxide. The manufacture of caprolactum, methanol and certain drugs has been started and new techniques, such as continuous production of DDT, dibutylphthalate, butanol, etc., have been introduced. In 1951 the industry was stated to have fulfilled the output plan by an average of 106%, but it was admitted that production of a number of important but unnamed materials was lower than expected. A resolution was consequently issued by the Communist Central Committee stating that the industry was not meeting the requirements of the national economy.

A list of the main causes of the inadequacy of the Czechoslovak chemical industry's output makes it plain that the central planning which has been ruthlessly introduced in all the countries in the Russian sphere has not by any means yielded the desired results in this case. For instance, reference is made to shortcomings in technology and in the organisation of production, an unsatisfactory state of plant and equipment, inadequate measures for preventing breakdowns, insufficient mechanisation, lack of measures to ensure sufficient qualified workers, and shortcomings in safety and health measures. Wages, too, were criticised and, above all, the expansion plan for the industry was considered to have serious defects.

A number of measures are to be taken by the Government to bring the industry to heel. Whether these will result in more and better chemicals being produced is another question.

Waste steam for works heating

WASTE steam from two 5-ton steam hammers at Firth-Vickers Stainless Steels Ltd., Staybrite Works, Sheffield, is now heating $3\frac{1}{2}$ acres of works, administrative and works offices and the canteen. To produce the same amount of heat by steam from boilers would take 1,200 tons of solid fuel each winter.

The nine boilers, electric fires and coke stoves formerly used for space heating are no longer necessary. There is also a saving of 800 gal. hr. of hot water. By returning condensate to the boiler, over 4,260,000 gal. of mains-supplied water are saved in the heating season. This is the first application in Britain of a system which can save the nation large quantities of fuel each year.

There were difficulties to be overcome, chiefly that oil in the exhaust steam would reduce heat transfer in the heating system and might cause trouble in the operation of steam traps, while condensate fed back to the boilers would be badly contaminated. Other objections were the possible reduced effectiveness of hammer blows and the intermittent supply of exhaust steam depending on the working of the hammers.

A system of applying graphite lubrication eliminates the oil normally discharged with the waste steam. Exhaust steam from both hammers is now led round the works through a simple overhead pipe system, unit heaters and radiant panels. In summer, exhaust steam blows into the air. Live steam to the hammer is reduced by a device controlled simply by the hammer operator's weight as he steps on and off a specially designed platform.

Another feature of the scheme is the provision of low-temperature radiant panels, giving local heat to operators on grinding units. With the high rate of air change due to doors being frequently opened, whole shop heating would be extremely difficult. The changes have also brought a cleaner atmosphere, since oil-impregnated steam no longer pollutes the air.

New technique in nickel mining

THE force of gravity has been put to work deep beneath the earth's surface in a vast mining programme that is helping to maintain nickel supplies. It has given mining science the key to recovery of millions of tons of nickel-copper ore once regarded as worthless. Engineers of the International Nickel Co. of Canada Ltd., at its mines in the Sudbury district of Canada, have recently adapted a mining technique by which large masses of ore, deep underground, are induced to cave and disintegrate by their own weight, according to R. L. Beattie, vice-president and general manager of the company's Canadian operations. The idea came from observation of the natural tendency of the lower-grade ore to subside and break up after higher-grade ore beneath it was mined out.

Called 'induced caving,' this low-cost bulk mining method, plus metallurgical practices, makes it practicable to

recover and treat ore lower in grade than has ever been worked in underground mining. Thus the supply of economically available ore has been increased. In caving, a 'slice' which may contain as much as 1,500,000 tons of ore is undercut. As ore from the undercut slice is withdrawn, the slice to be mined breaks away and starts to disintegrate as it moves downward, the weight of the upper part of the mass acting to crush the ore at the bottom.

Another bulk mining technique by which the company is increasing its underground production is the 'blasthole' method. Blasthole mining differs from caving only in so far as explosives are used to break the slices of harder, tougher ore from the solid material. The force of gravity then takes over, as in caving.

Yugoslavia's mercury industry

SINCE the cession of Istria to Yugoslavia after the war, some 11% of the world's output of mercury has been produced in the country and she is Europe's third largest producer after Italy and Spain. Some nine-tenths of her mercury output is exported, mainly to U.S.A., Switzerland, Scandinavia and West Germany. Chief source is the Idrija mine, which has been extensively developed since 1945.

This mine achieved a record output of 505 metric tons of mercury last year. During the first half of this year output was on the same level, and it is believed that Idrija will again produce over 500 tons of mercury this year. These are the highest production figures since exploitation of the mine began over 450 years ago. Before the war annual production averaged about 300 tons.

While Yugoslavia's output of mercury has been rising steadily since 1945, when it amounted to only 141 tons, the metal content of the ores mined has been falling with equal steadiness. In 1940 it was about 0.8%, in 1947 0.6% and in 1951 0.45%. In 1940, 154 tons of ore were required to produce 1 ton of metal; by 1951 251 tons of ore were required.

However, despite the fall in metal content of the ore, output of mercury at the Idrija mine should continue to expand and in three or four years' time it is expected to reach 600 tons a year.

Other mercury mines in Yugoslavia are at Sveta Ana, Knapovze, Litija and Marija Reka in Slovenia, at Maraska and Cemernica in Bosnia-Herzogivina, at Avala and Donja Tresnjica in Serbia and at Sutomor in Montenegro. These provide negligible quantities in comparison with the Idrija mine, however. From the liberation of Yugoslavia to the end of 1951 the Idrija mine produced 2,591 metric tons of mercury, compared with 787 tons for all other Yugoslav mines. It is for this reason that most of the extensive exploration now being carried out for mercury is concentrated on the Idrija mine.

A year's research on tin

WITH the opening of new laboratories at Greenford, Middlesex, last year (see this journal, July, 1951), the Tin Research Institute have begun several new investigations and a brief account of them is given in the recently published report for 1951. Facilities now exist for the testing of alloys in the form of actual bearings and the casting of bronze in the form of long bars. Chief interest, however, has been centred on pilot stage work on electrodeposited tin-alloy coatings.

A tin-nickel alloy plating process was developed during 1950 and a pilot plant is now in operation in the laboratories. As a result of tests this new plating process has been found satisfactory for a wide range of domestic metal ware, automobile and electrical appliances. A large commercial installation of about 2,000-gal. capacity has been in operation in Birmingham since 1951. A second commercial plant is in use in the U.S.A.

The corrosion section has given technical service to many tin users, including the food industry, makers of collapsible tubes for pharmaceuticals, refrigeration machinery manufacturers, etc. In addition to a wide range of tests of the corrosion resistance and protective value of various coatings, an investigation has brought out the high value of tin-zinc alloy coatings on steel bolts used in aluminium structures, not only to protect the steel, but to reduce the electrochemical corrosion of aluminium.

The Institute is continuing its policy of sponsoring research in other organisations. The theoretical study of the formation of tin-alloys is proceeding at Birmingham University. At the Fulmer Research Institute, where aluminium-tin alloys have been investigated, work has continued on the bearing alloys. At the University of Delft the investigation of the opacifying power of tin oxide has continued, and the effects of the composition of the frit have been studied.

Accident-free factories

MUCH progress has been made in accident prevention since the days of the Industrial Revolution, culminating in the factory legislation of modern times. Speaking at the recent National Industrial Safety Conference organised by the Industrial Safety Division of the Royal Society for the Prevention of Accidents, Dr. W. G. Hiscock, general manager of Imperial Smelting Corp. Ltd., said that once accidents had been accepted by industry as one of the major problems of factory life, and once an appeal had been made to top management it was amazing what progress could be made. In a dyestuffs factory in which he worked in the early thirties the accident frequency rate had been reduced in three years from over 4 accidents per 100,000 manhours worked to 1.22 per 100,000 manhours. By 1935 there had been an accident-free period of nearly 700,000 manhours and by 1937 well over a million accident-free hours had been worked.

However, results like this can only be achieved by long and persistent application of a sound policy formulated after co-operative study by all the people concerned in the enterprise. In addition, a national state of mind must be created so that the individual becomes conscious of the safety of himself and of others at all times, whether he is at work or crossing the road. Accident prevention should be taught at school so that the child grows up fully conscious of the hazards around him. Introduced into factory life on a sound basis during apprenticeship a person will then automatically bring his training to bear.

The designers of plants must also be safety conscious. Dr. Hiscock commented on the number of plants he had encountered which were so designed that operators 'have to be contortionists or monkeys to shut off a valve or make an adjustment.' In other cases, stairways are made for going down backwards and floors have quite unsuitable surfaces.

The future of industrial accident prevention depends on constant co-operation between managements and workers. Both are equally responsible and their attitude should be what can 'we' do to prevent accidents.

Liquid Cyclones

By S. Hesling, M.Sc., A.R.I.C.

As pointed out by the author in a previous survey of classification, sedimentation and thickening,[1] equipment developments in this field are infrequent. Thus, there will be especial interest in a new machine, the liquid cyclone, which has been developed over the past few years. In comparison with other machines of its type, the liquid cyclone is cheap to install and to run. Furthermore, it has considerably higher capacity. Industries in which it is being used successfully include coal preparation, heavy chemicals and metals. Here is a description of the development, design, construction, applications and performance of the liquid cyclone.

WHILE a patent for a cyclone-type thickener was granted as early as 1891[2] the cyclone separator process, as now understood, was developed by the research department of the Dutch State Mines about 12 years ago. It has been applied in the Staatsmijnen loess process to thicken the diluted loess or sand suspension obtained from the rinsing water of the washed products. The difference between the cyclone thickener and a normal settling tank is that the former makes use of centrifugal force, whereas the latter utilises the force of gravity alone.

Theoretical aspects

The working principle of the cyclone thickener as applied to coal slurries has been described by Driessen,[3] who has also outlined the reasoning which led to the development of the cyclone as a thickener and later as a washer.

Mechanisation of mining has increased the percentage of clays, silts and high-ash material in run-of-mine coal and attention has been drawn to the fact that the economical treatment of fine coals depends on the application of a method of separation other than by gravity alone.

The motion of small particles in a separating tank is approximated by Allen's formula:

$$W = \left(\frac{4g}{30\rho\sqrt{\Phi}}\right)^{2/3} d\left(\rho_S - \rho\right)^{2/3}$$

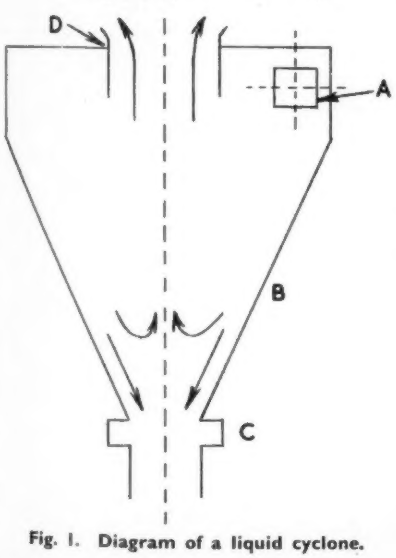

Fig. 1. Diagram of a liquid cyclone.

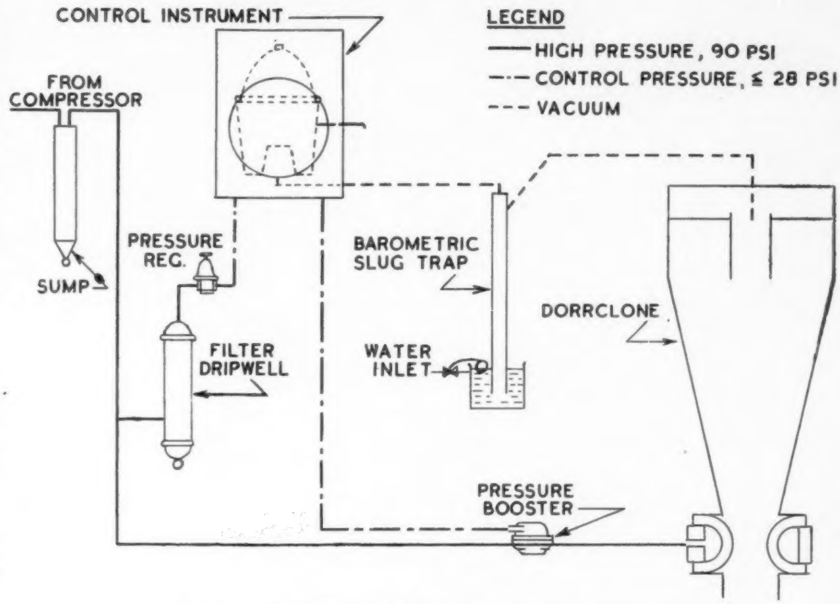

Fig. 2. Automatic underflow density control system.

where w = velocity of fall of a sphere;
d = diameter of the sphere;
g = acceleration due to gravity;
ρ and ρ_S = specific gravity of fluid and sphere;
and Φ = kinematic viscosity of the fluid.

This formula shows that in order to increase the velocity of fall w, the only feasible solution depends on either reducing the viscosity of the separating fluid, to which there is a practical limit (namely, the viscosity of water), or on 'increasing' the acceleration due to gravity.

Whilst subjecting the separating tank to centrifugal force would increase g, the application of such a principle on an industrial scale is not easy. Apart from the difficulty of making centrifuging continuous, the separating fluid would have to be a true liquid and such liquids are expensive. In addition, the 'liquid hold-up' in the product of a centrifuge, being dependent on surface area, would be high.

For these reasons laboratory studies of the liquid cyclone were initiated.

Operation

The theory of flow in a liquid cyclone has been discussed in some detail.[4, 5] It is intended to present here a working picture of its mechanism which is analogous to that of the gas cyclone.[6]

A liquid cyclone is shown diagrammatically in Fig. 1. The slurry under treatment is fed to the top of the cyclone through a rectangular duct *A* of variable area. This duct is disposed tangentially to the main cyclone body. Introduction of the feed tangentially gives rise to a vortex flow pattern within the cyclone, which throws coarse particles to the outside wall of the conical section *B*. These particles leave at the base through the adjustable apex valve at *C*, and it is often referred to as the underflow. The finer particles move upwards in the centre of the cyclone chamber through the vortex finder *D*. This overflow is then piped away.

It is generally considered that in an operating cyclone the centrifugal forces which act on the fine particles present in a slurry are sufficiently great to cause them to overcome the restraining influence of the slurry itself, and settle through it.

Control

The density of the underflow from the apex of a cyclone is a function of the apex orifice diameter, assuming feed rate and feed analysis to be constant. The density

of the underflow may therefore be controlled by varying the apex orifice opening to encounter variations in feed rate and composition. Decreasing the apex valve opening increases the underflow density.

To effect this balance, an automatic control system has been developed,[7] which is based on the variation in magnitude of the vacuum which exists at the centre of an operating cyclone. The apex orifice valve may be in the form of a rubber tyre; when actuated by the control device the tyre is inflated to close its inner diameter. A diagram of such a system is shown in Fig. 2.

The rate and pressure at which the feed is introduced to a cyclone are the principal means whereby the centrifugal forces in a cyclone are controlled; therefore they vary with the range of sizes present in the feed. Separation of the finer sizes requires higher pressures than are necessary for the larger particles.

Thus, use of adjustable feed nozzles, interchangeable vortex finders and an automatic apex orifice control, allows a flexibility of operation with regard to the size of separation and the volumetric capacity, whilst maintaining a constant underflow density.

An example of this flexibility is provided by the results presented in Table 1. These were obtained using a 3-in. and a 6-in. diameter cyclone to which a silica sand and a quartz mill tailing were fed.

Materials of construction

It has been stated that wear of cyclone washers and thickeners to which coal fines are fed is not excessive. The conical portion and the apex orifice valve wear badly after prolonged service. The extent of this wear depends on the maximum size of particle present in the feed, coarser particles causing greater wear.

Designs have been described[3, 8, 9] which aim at eliminating this nuisance or reducing the out-of-service time of such equipment. The conical portion of the cyclone is made so that it can be replaced easily and one 14-in. diameter cyclone thickener, lined with a ½-in. layer of soft rubber has shown little wear after 2,500 hr. in service. The top size of the material fed to this cyclone was 16 mesh.

The worst wear in a wet cyclone occurs just above and at the apex orifice valve. Orifices of rubber have proved to be a success; in cases where rubber has not been successful this section of the equipment appears to be regarded as replaceable and is designed for easy removal.

Applications

In the classification of solids the liquid cyclone is applicable to the separation of fine mineral or coal particles in the size range minus ¼ in. down to 65 mesh, when fed with a medium of suitable specific gravity. Data obtained from tests carried out on laboratory and industrial equipment under a wide range of operating

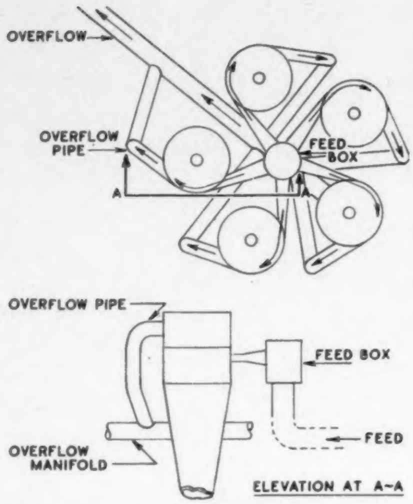

Fig. 3. Compact arrangement of five cyclones.

conditions have already been presented.[3, 7]

Some typical applications, outside the field of coal preparation, include the treatment of non-metallic minerals such as phosphate ores, prior to concentration, the removal of grit from pigments, the classification of abrasives down to 10 microns, the production of specific size ranges of silica and quartz sands, and the concentration of metallic ores.

Another series of applications lies in the ability of the wet cyclone to carry out size separations in the micron size range, on naturally flocculent slurries, without the use of dispersing agents or dilution. Its success in such cases is presumably due to the action of the shear forces within the cyclone.

The use of the wet cyclone as a thickener and a washer for coal preparation has already been mentioned. As a washer it sharply separates fine or small coal. Such coal, with an ash content of about 2%, is necessary for hydrogenation, and in the manufacture of electrode cokes.

The application of liquid cyclones to the control of the solids content of circulating water in two coal preparation plants in America has been described in detail.[8, 10]

Advantages and disadvantages

In comparison with conventional equipment for classification, sedimentation and thickening, such as settling cones, drag and spiral classifiers, tank thickeners and hydroseparators, the wet cyclone has the advantage of low capital cost and, because it contains no moving parts, low maintenance costs. The capacity of wet cyclones, expressed in terms of gallons per hour of slurry handled per square foot of floor area, is of the order of ten times that of conventional equipment.

Table 1. Classification of Sands

Material	*Silica sand*			*Quartz mill tailings*		
Test	1	2	3	4	5	6
Cyclone, in. diam.	6	6	6	3	3	2
Feed nozzle, sq. in.	0.75	0.75	0.75	0.19	0.19	0.75
Vortex finder, in. diam.	1	1⅜	1⅜	0.49	0.49	1.38
Vortex, in. diam.	< ½	< ½	< ½	7/16	7/16	¾
Pressure, p.s.i.	35	35	5	40	40	30
Feed, % solids	2.6	2.16	4.42	32.6	23.9	25.4
Overflow, % solids	1.6	1.6	4.0	16.3	9.21	13.2
Underflow, % solids	71.2	55.0	49.4	70.3	69.0	71.6
Weight underflow: weight feed	0.391	0.271	0.103	0.65	0.71	0.591
Feed, gal./min.	36.3	54.1	23.4	19.6	15.7	62.4
Overflow, gal./min.	36.0	53.7	23.2	15.5	13.1	53.8
Underflow, gal./min.	0.3	0.4	0.2	4.1	2.6	8.6
Separation, microns	25	32	42	35	27	74
Solids, sp. gr.	2.65	2.65	2.65	2.65	2.65	2.65

Table 2. Comparison of Performance of Fine Coal Washers

Type of unit	*Grain size m.m.*	*S.G. of separation*	*Ash content Clean coal %*	*% Efficiency* Theoretical/effective yield*
Pneumatic	0.5—3	2.00	10.0	97.9
Froth flotation	0.05—1	1.72 2.01	6.6 8.8	98.2 98.3
Laminar (Vogel)	3—10 0.5—3	1.30 1.315	2.5 3.55	67.0 66.0
Jig†	0.5—8	1.50 1.71	4.6 6.35	91.8 98.4
Rheolaveur	0.5—5	1.50 1.80	4.6 6.9	86.8 98.7
Cyclone	0.7—8 0.5—8	1.53 1.79	4.25 6.25	99.5 99.8

Ash content and efficiency based on feed analysis.
*Theoretical yield computed from the washability curve at a certain % ash content of the washed coal.
†Jig washer with re-washing of dirt on classifier.

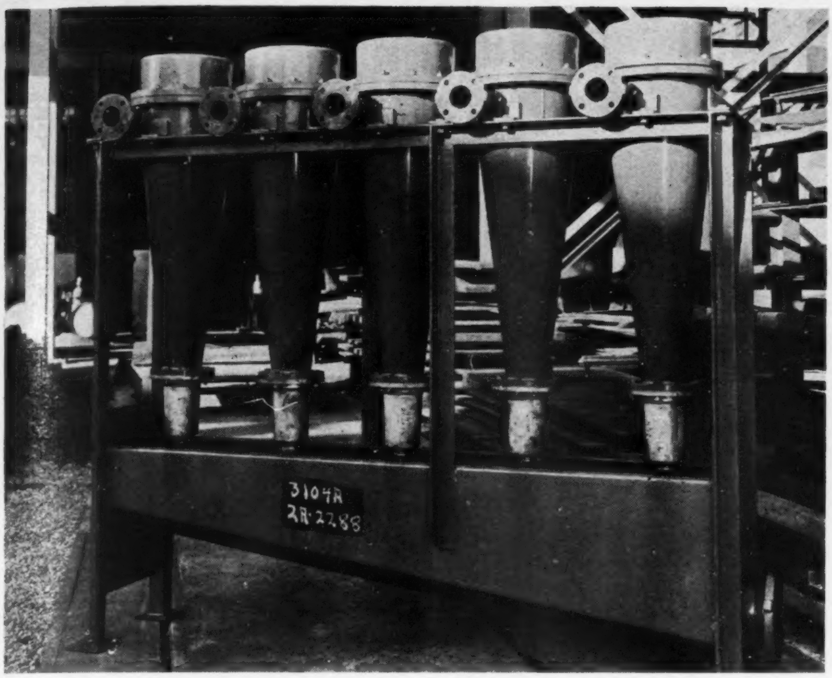

Fig. 4. A bank of five 14-in. diameter cyclone thickeners.

This advantage of increased capacity is countered in part by the high-pressure drop which exists in operating cyclones. This necessitates the use of pumps which will deliver the feed at pressures from 10 to 40 p.s.i.g., depending on the application.

In general it would seem that the wet cyclone has real advantages for such operations as dealing with flocculent slurries and in coal washing. In both these applications the cyclone carries out the desired treatment better than any other single piece of equipment at present available. Driessen has stated[3] that the only economical and practical solution to the cleaning of fine coal, using a low specific gravity of separation or at low ash content, is the cyclone washer. A comparison of the performance of the various fine coal washers is given in Table 2.

Future developments

With regard to the capacity of wet cyclones it should be stated that at present a large number of small cyclones is used to handle high feed rates. For example, a 14-in. diameter cyclone washer handling 15 tons/hr. has been described. It is possible that future developments will enable larger single units to be used, whereas at present ten 14-in. diameter units would be used to handle 150 tons/hr. Fig. 3 shows an arrangement which has been proposed for combining multiple cyclones in a minimum space. A bank of five 14-in. diameter thickeners is shown in Fig. 4.

Experimental work, not complete at the time of writing, is being carried out to determine the usefulness of the liquid cyclone in de-sliming or classification of coal down to 200 mesh. An expression enabling the estimation of cyclone dimensions for a given duty has already been presented.[11]

At present the application of the cyclone on an industrial scale to the treatment of a given slurry must necessarily be preceded by laboratory tests.

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Acknowledgments

Figs. 2, 3 and 4 are reproduced by courtesy of *Mining Engineering*. Fig. 4 also by courtesy of Heyl & Patterson Inc.

Continuous method speeds soapmaking and cuts waste

An automatic hydrolysing unit and a continuous, high-temperature, high-pressure process is being used by some American soap manufacturers instead of bath saponification. The method is said to permit volume production of soaps of good quality with a minimum of waste, and the amount of chemical treatment required is minimised. Complete information regarding the continuous method has not yet been published. However, it is understood that it can produce a good soap of uniform quality in only 8 hr., with less than 1% of waste. Similarly, three varieties of soap may be produced from the same continuous equipment in 24 hr.

The first step in the process, as described in *Soap and Sanitary Chemicals*, April 24, 1952, involves the thorough mixing of the various oils required by the soap formula. Dehydration immediately follows the mixing and, after dehydration, the oil and water are passed through a series of heat exchangers into a hydrolysing unit which splits the contents into free fatty acids and glycerin. The ratio of water to oil in the hydrolysing unit is governed primarily by the need to obtain 99% hydrolysis. While the flow rate of oil and water in the hydrolyser is approximately equal, the conditions of temperature and pressure may vary according to the nature of the stock. After leaving the hydrolyser, the fatty acids are preheated to 300°C. and are passed into a high-vacuum zone within a still, where they are vaporised and condensed to form a distillate that is converted into soap. A residue of 'tailings' that constitutes approximately 8 to 10% of the entire charge is left as a result of the distilling operation. 'Tailings' can be salvaged either through use in soaps of lesser quality or through recovery of the fatty-acid content by acid washing. 'Tailings' incurred in the third-quality blend, which amount to less than 1% of the entire production, comprise the only residue that is lost completely. This final 1% residue may be disposed of to tar distillers.

Acids and bases

This monograph* attempts to give a brief and unified account of the applications of theories of acids and bases to a wide variety of chemical problems. The first two chapters are elementary in nature and then come chapters on acids and bases in non-aqueous solvents, interionic attraction in acid-base equilibria, acid-base strength and molecular structure, and acid-base catalysis. The book ends with a discussion on alternative uses of the terms 'acid' and 'base.' As will be gathered from the title, the emphasis throughout the monograph is on the quantitative aspects of acid-base behaviour.

**Acids and Bases, their Quantitative Behaviour*, by R. P. Bell, F.R.S. Methuen, London, 1952. Pp. 90. 6s. 6d. net.

Chemical Engineering in the U.S.A.

CURRENT IDEAS AND TECHNIQUES OF AMERICAN CHEMICAL ENGINEERS

By J. M. Coulson, M.A., Ph.D.

Forty years ago the chemical and petroleum industries in the United States were insignificant. Today they are the biggest in the world. In this phenomenal expansion the American chemical engineer has played a leading rôle and in so doing has raised the status of his profession all over the world. To investigate and interpret for Europeans the contemporary American chemical engineering scene, eleven experts from ten different countries in Europe recently toured the United States. Their report, 'Chemical Apparatus in the U.S.A.,'* is a document which should be required reading for all chemical engineers and industrial chemists. Here the report is comprehensively reviewed for CHEMICAL & PROCESS ENGINEERING by a member of the Chemical Engineering Department of Imperial College, University of London.

THE United States has raised and developed the chemical engineer to a high and, indeed, key position in her petroleum and chemical industries. She has supplied the world with texts and with her technical journals has built up a profession of the greatest importance. This new report, sponsored by the Organisation for European Economic Co-operation, is really a study of the American chemical engineer, his training, his methods, his outlook and his achievements. It is valuable in that it puts on the European stage in a concise form the great part these men have played in the growth of the petroleum and chemical industries.

Many teams of trade union members, foremen and managers of British industries have reported on the high productivity of a wide range of American industries. This report, by a group of 11 experts with Prof. A. H. M. Andreasen, of Denmark, as chairman, is quite different, for its members come from 10 different European countries (Denmark, Norway, Belgium, Greece, Sweden, France, Holland, Italy, Austria, U.K.). The Mission included three professors of chemical engineering or technology, three directors of chemical plant construction and one instrument specialist from England (A. J. Young, head of I.C.I.'s Central Instrument Section). It is important to realise that they are writing for Europe, where the individual countries differ among themselves, and where in each country there are progressive companies and those which are badly behind in techniques.

In 1916 the chemical industries in America were insignificant compared with those in Europe, where there also existed an established tradition of fundamental science. Yet in 40 years America has reached equality in techniques of industrial chemistry and superiority in the construction of chemical plants. This is disturbing when it is realised that Europe still plays a distinguished part in fundamental and applied science. Thus, DDT, *Gammexane*, antimalarial drugs, penicillin and acetylene derivatives are all of European origin. Again, some of the important techniques, such as azeotropic and extractive distillation, have long been used in Europe, but it has been America that has pushed them to full commercial exploitation. Several reasons are frequently put forward to explain this rapid rise in American chemical industry: the abundance of raw materials, the avoidance of destruction in two wars, the spirit of enterprise in industry and the relish of novelty by the consumer. On the other hand, to quote the report, 'in view of the unanimous statements of the American experts met by the Mission, it must be emphasised that a large part of the success of the great American achievements in industrial chemistry is due to the efficiency of the chemical engineer. The action of the chemical engineer is decisive when a process is transposed from the laboratory to the industrial state.'

Scope of the Report

The main objects of the Mission were:

(*a*) A general study of the methods employed in the design and construction of the chemical installations.

(*b*) Special studies of the methods employed in the development and utilisation of control instruments, and of the maintenance methods used in the chemical industry. An examination of the materials of construction and of transportation and storage of chemical products.

Visits were made to some 20 companies, including seven chemical engineering contractors, seven equipment manufacturers and two instrument makers. The report might have been better balanced if it had included the views of chemical companies.

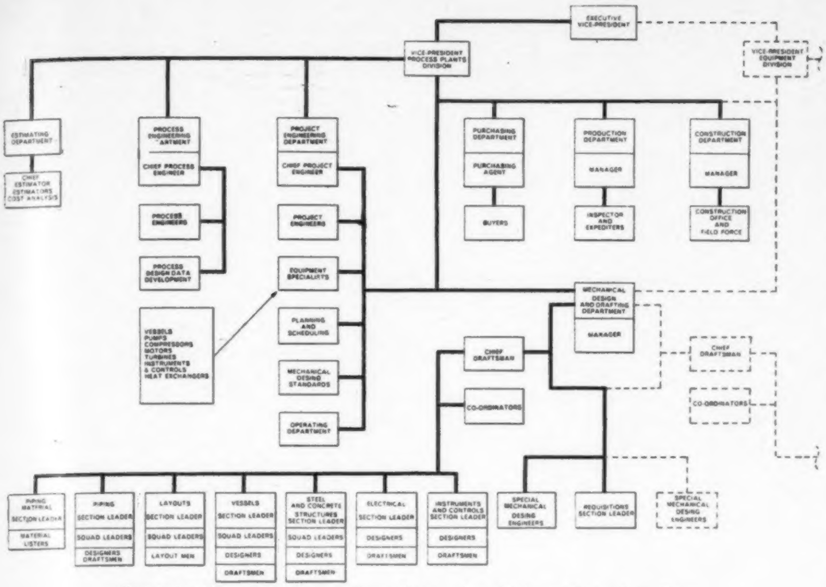
The report is divided into two main parts. Part 1, of four chapters, covers the chemical engineer, the need for him, his training, field of employment, particularly in the construction companies, standardisation of equipment and a discussion of the working methods of the American chemical industry. Part 2 is devoted to process instrumentation, catalytic processes in the petroleum field, methods of separating homogeneous mixtures, heat exchange and miscellaneous equipment. The last two chapters deal with materials of construction and transportation and storage of products. Part 1 is the most important, since much of the information of part 2, although valuable, is already largely available in the technical journals.

Training

As defined in the report, the chemical engineer is primarily concerned with the industrial application of the physical and chemical changes of material through the theories of unit operations and applied chemical kinetics. He is neither a chemist with some knowledge of engineering nor a mechanical engineer with some knowledge of chemistry, but has a field of activity of his own. It is necessary and good to go on saying this, since it is the heart of the failure in Europe to keep abreast of American techniques. This view agrees with that of Sir Harold Hartley, who described chemical engineering as the fifth primary technology in his presidential address to the Institution of Chemical Engineers this year. The interests of the chemist are focused on chemistry, those of the mechanical engineer on mechanical design and construction. These fields are wide apart and there is little mutual comprehension. In Britain, at least, the increasing specialisation of chemical courses is widening the gap between the engineer and chemist, and it is unfortunate that so many chemists today have no appreciation of applied mechanics.

Chemical engineers are trained in universities, technical institutes and in industry. The academic institutions provide a theoretical background, but for process and equipment design the best advanced training is provided on the job. It is important to note that in America the educational system has always striven first to serve the needs of industry rather than the

* H.M.S.O., London, 224 pp. Illustrated. 20s. net.



Organisation of a large American chemical engineering firm.

advancement of science. In these courses the student must learn, and in America it seems more natural, that empirical procedures must be used with avidity to fill in the gaps in our theoretical knowledge.

American courses normally take four and a half years and, in the main, are taken in a separate department of chemical engineering. It is very important to note that from 10 to 30% of the B.Sc. graduates stay on for one year to get an M.Sc. or for three additional years to get the Ph.D. It is also common practice for students to return to the university after spending a few years in industry.

The present curriculum for the chemical engineering course in London does not differ substantially from that in America, but the shorter period of three years means that less ground is covered. In Britain the demand for laboratory work in unit operations is realised and there are a number of colleges with facilities in this respect, but it is rare to find any attempt made to run small process plants as part of the study of chemical reactions.

However, the outstanding difference is in numbers, for whereas America is turning out 2 to 3,000, we are producing about 200 final-year graduates a year.

Employment

This is a valuable section of the report, as it brings out the wide range of jobs open to chemical engineers in America. The distribution by occupations is shown in Table 1.

The predominance of research and development is another instance of the importance attached to applied research in America. This trend also occurs in Britain; most of the graduates from at least one college take up development work in the chemical and petroleum companies; about $6\frac{1}{2}$% go to engineering contractors.

Table 1. Distribution of Chemical Engineers by Occupation

	%
Research and development	30.6
Production, operation and maintenance	22.1
Management and administration	10.5
Inspection, testing, process control	7.9
Design, construction, installation	6.5
Technical service and sales	2.9
Teaching	1.6
Others	17.9
	100

Table 2. Chemical Engineers Employed 1945 (per 1,000 Registered Engineers)

Industrial chemicals	225
Petroleum refining	131
Explosives	40
Plastics	38
Synthetic rubber	25
Food products	22

Table 2 shows some selected data on the distribution of American chemical engineers amongst industries.

Pilot plants

Whether or not a process should be tested on a pilot plant is a difficult decision for the chemical engineer. This work is very expensive and should only be undertaken if the data cannot be obtained in any other way. Research is at present being undertaken to discover the ways in which applied chemical kinetics can help in designing large-scale reactors from laboratory data. The chemical engineering contractors have all agreed that this work takes a long time and that where possible it would probably be cheaper to buy the data.

This question of pilot plants illustrates one very big difference between petroleum and chemical plants. In the petroleum industry several commercial plants may be built from one pilot plant, while in the chemical industry usually only one plant is built. The difficulties in scaling up chemical units are greater than with petroleum, the handling of solids and residues presenting additional complications. In the petroleum industry the ratio of the full-scale to the pilot plant is usually between 2,000 : 1 to 5,000 : 1. They must always be flexible and provide a range of operating conditions.

Process and equipment design

This work is done both in the chemical industries and in the construction firms. By process design is meant the calculations required to give the size of the individual units, heat and material balances and operating conditions. Included is the problem of collecting the required data from physical chemists or elsewhere. This work is particularly that of the chemical engineer. Equipment design refers to the mechanical details of construction and may be done either by chemical or mechanical engineers. This work undoubtedly requires specialists and the industrial chemical engineer is not really equipped to do it. Instrumentation enters here and again is the province of a specialist.

These varieties of work, research, pilot plant, process and equipment design absorb most chemical engineers. Whilst no details are given of the methods of the big chemical companies, they undoubtedly provide rich opportunities for this class of work, apart, perhaps, from equipment design and actual construction.

We shall now turn to perhaps the most fruitful part of the report covering the chemical engineering and construction firms.

Chemical engineering and construction firms

There are about six large and some 25 to 30 smaller firms of chemical engineering contractors in America engaged on development, design and construction of plants for the chemical and petroleum industries. On the basis of pilot plant work carried out by themselves or their customers they design the plant and most of them order the components, erect and start up the plant. Fabrication is largely left to sub-contractors, though some of the firms have large factories of their own. Some of the firms develop processes of their own, *e.g.* the *Houdry* catalytic cracking and the *Solexol* extraction processes. One of the largest firms claims to handle annually projects estimated to cost $200,000,000 (about £70,000,000). This is an enormous figure and may be contrasted with the £190,000,000 estimated for new construction in the whole of the British chemical industry for a period of five years in the report published by the Association of British Chemical Manufacturers in 1949.

These firms have been mainly successful in the petroleum fields, where the projects are too large for the refiner's own engineering staff. They enjoy in the petroleum field the benefits of a free exchange of information, and can build up specialist teams which enable them to undertake

what amounts to repeat jobs at very economic terms; customers do not hesitate to accept the engineering of these firms. In the chemical field the secrets of new processes and of improvements are guarded and, moreover, the projects are smaller and can be handled by the engineering division of a large firm. Here the contractors have been limited to boiler plants, fractionating equipment, *Dowtherm* heating, gas plants and other sections where many firms use the same process, and hence the contractor can pass on his experience from one firm to another. Thus the two largest firms visited reported that 80 to 90% of their activities are concerned with the petroleum industry. All the firms, however, were very interested in expanding in the chemical field.

These firms each employ some 600 to 1,200 persons in their design establishments and in one the breakdown of staff was 45% engineers, 35% draughtsmen and 20% buyers and clerks. They all employ separate departments for process design and for equipment design, and one firm had 50 fully-qualified chemical engineers in its process department. The process department provides material and energy balances, heat requirements and sizes of main plant items, such as reactor columns. They also collect general data for process design. The organisational charts, one of which is reproduced on the previous page, show a high degree of specialisation. Thus, separate sections deal with vessels, heat exchangers, pumps, compressors, instruments, etc. This method enables each engineer to be quick on his particular problem and is the main reason for the high efficiency of the firms, but steps must be taken to prevent men becoming too specialised in their work.

The job engineer

The high degree of specialisation in these firms has brought into existence a coordinator known as the 'job engineer.' The specialists are concerned with a number of different projects simultaneously, but the job engineer is assigned to one major or perhaps a few minor projects. His job is to see that the required information reaches the design engineers and that the equipment fulfils both the process requirement and the customer's wishes. Above all, he is responsible for seeing that a time-table is maintained and that the work is completed to schedule. Whilst not directly responsible for starting up, he writes the 'trouble' report for the engineers. It is difficult to find such a man in the constructional firms and he is often recruited from outside, since he must have had a wide variety of operational experience. Big firms move young engineers round as far as possible, but undoubtedly there are disadvantages as well as advantages in these highly specialised methods. As one vice-president said, he gets projects done on a production line, the individual specialists forming the line, but the oiling and speed of the line is kept up by the job engineer.

Recruitment

The process departments are staffed almost entirely with chemical engineers, while the project engineering departments are equally divided between chemical and mechanical engineers; the equipment specialists are mainly mechanical engineers. For chemical engineers an M.Sc. is usual and the Ph.D. considered highly desirable. The cream of the young chemical engineers go into development and design work. There is an incentive for technical staff in that every rise is dependent on the quality of the work done and promotion is by merit and never by age or seniority.

These firms are aided by the extensive service of the equipment suppliers, so that filters, pumps, instruments, etc., can be bought easily and the design engineers are not bothered with them. These big firms make extensive use of sub-contractors wherever they think that the smaller firm can do a better job. The costs are cut by standardisation and simplification, which has been carried much further than in Europe.

The large firms have made a major contribution to the rapid expansion of the petroleum and allied industries by providing excellent design engineering and emphasising the engineering aspects of the development of new processes. They operate branch offices in Britain, but, as stated in the report, practically all the process and fundamental design work is done in America.

As suggested in the report, European firms should examine their methods to see if they cannot apply the principles of specialisation, sub-contracting, standardisation, etc., which have contributed to the efficiency of the American companies. With the increasing refinery and allied work going on in Britain, there is surely an opportunity to acquire the technical methods of American firms. Are we to buy American know-how for ever?

Standardisation

Standardisation is used by the chemical plant industry to a greater extent than in Europe. The large companies all work with standards which in many cases become national standards. The American Society for Testing Materials and the American Petroleum Institute are both active in producing widely-used standards in addition to the Standards Association. In plant units, like glass-lined reaction vessels, the different degree of agitation is achieved by altering the agitator speed and the position of a standardised but adjustable baffle. In the range of heat exchangers there is also a considerable degree of standardisation.

We in Britain still do not fully appreciate the advantages of standardisation. The apparent complexity of the plant needs of the chemical industry should be regarded as an incentive to achieve simplification and standardisation rather than as an insurmountable obstacle to such an achievement.

Process instrumentation

This is the subject of the first chapter in part 2. In addition to visiting instrument makers, the subject was discussed with the chemical engineering contractors. A long appendix to the report contains a useful summary of the present forms of instrumentation, but much of this has already been described in the technical press. The real purpose of the chapter is to discuss the reasons for the high level of American instrumentation.

The most important reason is that instrumentation is universally regarded as vital to high productivity. There is little doubt that productivity in Europe could be increased by more instrumentation. To get industry into the instrumentation habit is the most difficult problem, and it is unfortunate, yet understandable, that no data could be collected by the Mission to show specific savings by instrumentation. It is recommended that British firms should make an estimate of what could be saved by instrumentation. In this context it must be realised that in the chemical industry instrumentation will scarcely save manpower, which is already at the minimum for safe operation. It will ensure a higher quality product over longer periods than manual control and it may be very useful in saving experienced operators for special jobs. However, the more instrumentation there is, the less skilled in control are the operators.

The report fairly points out that there are progressive firms in Europe with excellent instrumentation and that the British instrument makers are making a determined bid to catch up. The development of the all-electric three-action control is cited as an instance where Europe may claim to be ahead. On the whole, European measuring equipment is as good as the American, but good control equipment is only just becoming available. It is another field in which American aptitude and energy in applied engineering has made use of theoretical and early work from Europe.

The very large market of the oil industry and the active work by the instrument makers with their efficient service have all helped in the growth of the industry now centred in about 12 large firms. Education in instrumentation is given by the chemical industries, the instrument companies and by the colleges, where the chemical engineering course covers the theory and principles of controllers.

The main object of the makers is at present to increase the speed of response of control systems. Placing controllers on the 'production line,' near the detecting element, or by installing high-speed response systems are two of the methods being used. The development of miniature instruments to save space and of the graphic panel are further pointers. It would have been useful to learn whether the instrument firms prefer physicists to electrical engineers or *vice versa*.

(*Concluded on page* 504)

Graphic and Supervisory Control Panels

By Alan Pollard, B.Sc., A.R.I.C.

The development of centralised control panels in the process industries is briefly reviewed in this article. The use of a graphic presentation with instruments positionally mounted in a flow sheet of the process is shown to have many advantages over the large central control panel. The special instruments designed for this purpose reflect the change in the nature of the operator's duties following the application of automatic control. Typical supervisory instruments of this type and their use in graphic and console-graphic panels are discussed. Finally, the pros and cons of graphic panels are summarised. This is the last of three articles on automatic control. The first and second appeared in the July and August issues of CHEMICAL & PROCESS ENGINEERING.

IT is now generally accepted that instruments are indispensable to the operation of modern industrial processes, whether manual or automatic. In either case the use of process instruments presents a further problem to the designer: the method of presentation of these instruments to the process operators in order to ensure the maximum efficiency of operation. The problems of process design and layout vary so much that it is almost impossible to apply any general rules, but in most cases some form of centralised control is required.

Twenty to thirty years ago most chemical plants were operated batchwise. Control was generally based on chemical analysis of the product and the relatively few instruments required were simple—thermometers and pressure gauges, etc.—and were generally mounted directly on to the vessels of the plant. This local mounting of instruments is still preferred in most of the modern batch plants, in spite of the greatly increased use of instruments in these processes. Here it should be emphasised that the batch method is still widely used in industries where the output required does not justify continuous production, *e.g.* the dyestuffs and fine chemicals industries, and a number of food manufacturing processes. There is little point in centralising instruments and controls in these cases, since usually there are several small production units which require manual attention (*e.g.* filling and emptying) from time to time. Quite often, also, a variety of products is made in the same plant, requiring modifications in the plant layout and the method of control.

The development of continuous production processes has led to a considerable increase both in the development and the application of instruments. In a continuous process, chemical tests must be replaced by physical measurements. Since the plant capacity is relatively small and the throughput high compared with a batch process, a change in operating conditions produces a much quicker reaction in the process variables. Thus the plant is relatively more unstable and more difficult to control. For steady operating conditions a continuous rebalancing of the material and energy requirements is necessary, and the operator must be provided continually with a clear picture of the conditions in that part of the plant under his immediate control. Obviously, supervision is much more difficult if readings have to be collected from scattered points. Thus in processes of this type some centralisation of instruments and controls has always been necessary. At first the instruments were grouped together at some convenient point in the plant structure near to the valves used for manual control. Each of these stations would relate to a suitable sub-division of the plant and would be supervised by a separate operator. With increasing throughputs and closer integration of the plant it soon became necessary to combine these 'sub-controls' into a central control panel relating to a much larger section, if not to the whole, of the plant. Control valves were first operated manually from the panel by extension spindles or remote-setting devices, and then by automatic controllers on the control panel. Inevitably, as the size and complexity of the processes increased, the stage was reached at which the control panel was sufficiently large to occupy a separate room attached to the plant and, ultimately, as in many of the larger modern plants, even a separate building.

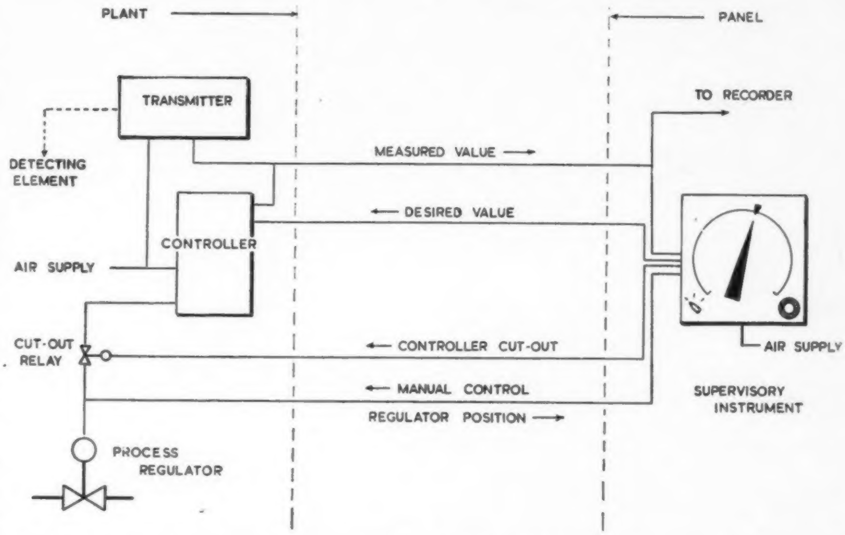


Fig. 1. Schematic diagram of a field-mounted controller with a supervisory panel instrument illustrating the essential transmission lines between the plant and control panel.

This centralisation, combined with the removal of the instruments from the plant, has many advantages irrespective of whether the control is manual or automatic. Principally the operator has all his information readily available and can see almost immediately the conditions at any moment over the entire plant. He is in a position to detect disturbances at the earliest possible moment and can concentrate on maintaining optimum conditions. The separate control room, adequately ventilated or pressurised, is also an ideal place for the mounting of instruments. Servicing and maintenance are much easier, and because they are sheltered, the useful life of the instruments is generally much longer than would otherwise be the case. The major disadvantage is the introduction of transmission lags, both on the measuring and controlling sides of the control loop, which necessitate the use of pneumatic transmitters or more elaborate control actions.

The increased application of automatic control has inevitably led to a still closer integration of the continuous process, from the raw materials through to the finished product, with intermediate storage space being almost completely eliminated. Today

designers think in terms of the entire process and its interrelated functions rather than of the specific variables which require individual control. As a result, the central control panel has tended to grow, until on a large and complex process such as a modern oil refinery, it is now so large that the essential simplicity for which it was originally created has now almost disappeared. On such processes it is no longer possible to maintain a continuous check on operation without the operator patrolling a relatively long control panel. As the number of instruments is increased the greater also is the possibility of confusion and the more difficult the training of new operating staff. Mistakes will arise because of the difficulty of identifying quickly that part of the plant to which a particular instrument is connected and the effect that adjustments to this instrument will have on the process. This problem, of course, is found on any panel embodying more than a very few instruments, and obviously becomes more serious as the number of instruments increases. On conventional panels the general plan is to locate the instruments on the panel in the logical order in which they occur in the process. Unfortunately this method does not illustrate the interdependence of any instruments, *e.g.* in a cascade control, and is particularly difficult to design when the process contains side- or parallel-streams or recycles. Any development lending itself to a reduction of confusion and an increased directness of approach will have obvious economic potentialities.

The graphic panel

A clearer interpretation of the function of the instruments in the process can be obtained by displaying on the panel a simple line flow sheet of the process and by placing the instruments in their proper positions with respect to the flow lines and units of the plant. Line diagram or 'graphic' panels of this type have been constructed with the conventional range of instruments, but a great improvement has followed the development of a special range of miniature instruments for this type of panel.

The graphic panel is not, of course, a very recent development; it has been in use in other applications for many years. For example, in electricity distribution networks, the control panel displays a diagrammatic 'map' of the network with relay switches and signals at the points on the diagram corresponding to the positions of circuit-breakers in the field. However, there is a fundamental difference between this method of use and that of process control. In electricity distribution it is the circuit which is changed; in process control the circuit, *i.e.* the layout of the plant, remains constant and it is the conditions in the circuit that are changed. Nevertheless, the basic idea of the graphic panel in any application is the same: to present to the operator all the essential information on a panel which has the appearance, even if highly symbolic, of the actual process. The operator on the plant would normally reach for a control valve in a certain flow line; the operator at the graphic panel reaches for the valve depicted on the diagram and finds there some means of adjusting the actual valve in the plant.

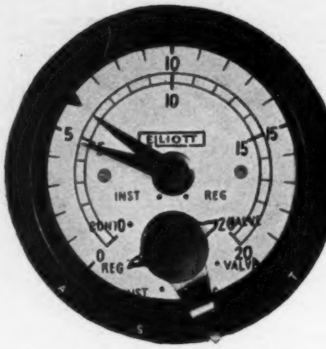


Fig. 2. Supervisory panel unit.

As was pointed out in a previous article, with the development of automatic control the duties of the process operator have become mainly supervisory. He has been relieved of the minute-to-minute control of the plant; his major duty is now a continuous supervision of operation by the controlling instruments, coupled with the necessity of adjusting or even overriding these instruments as his experience dictates in the event of a departure from the normal conditions. The recognition of this change in the nature of the operator's duties is reflected in the design of the 'supervisory' type of instrument developed for the graphic panel.

Generally, the adjustment of the automatic control actions such as proportional bands, etc., is not considered to be a part of the operator's duties, but more properly within the jurisdiction of the supervisory staff—the plant or instrument engineers or plant superintendents. These adjustments need not then be accessible to the operator and the controller need not then be mounted on the panel. The operator must, however, have a continuous indication of the state of affairs, *i.e.* a comparison of the measured and desired values of the controlled variable. In the event of a disturbance, he must also be able either to change the desired value to suit the new conditions or to take over manual control if the instruments are unable to restore steady-state conditions. The indication of the important variables, the desired values and these controls are the only facilities which the operator needs to have constantly before his eyes. So long as these facilities are made available on the panel, the actual controlling instrument can be placed at any suitable point between the control panel and the plant. Transmission of signals between the controller and the supervisory instrument on the panel may be either pneumatic or electrical. This method of operation gives two immediate advantages.

Initially, an immediate standardisation of instruments is possible, since all controllers and their supervisory instruments are identical in design and construction irrespective of the actual process variable, be it pressure, temperature, flow or level, which is being controlled. The only difference between the various individual control loops lies in the measuring units being used, since even the transmitting units will be essentially similar in operation if not in construction. As an example, when using pneumatic transmission, the input signals to the controller, both of measured and desired values, are air pressures in the usual standard range of 3 to 15 p.s.i., and the instrument is essentially a pressure controller with a pneumatically set desired value. Of course, special instruments have been designed for this purpose, but conventional instruments could readily be adapted if necessary. Since the essential units are now interchangeable, servicing is greatly simplified and overhaul in the workshop can replace maintenance work in the field.

Secondly, and of particular importance in pneumatic systems, is the possibility of mounting the controller on the plant, close to both the measuring unit and the regulating unit. It will be appreciated that the transmission lines from the controller to the supervisory instrument do not form part of the control loop, and this method of 'close-coupling' yields a control loop with the minimum transmission lags. The value of this is apparent in processes of short-time characteristics such as flow and pressure control where transmission lags may be relatively large compared with the fundamental time-constants of the control loop. Using this method it is possible to use narrower proportional bands and faster reset rates and thereby improve the quality of control obtained. This advantage generally outweighs the possible disadvantages of field-mounting the controller, the principal one being that the control actions are now decentralised.

Close-coupled control loops using a supervisory instrument are not, of course, restricted to use with graphic panels, but can be used in any application where centralised control is required.

With a thermal process or any other in which the process time-constants are relatively large, there is little advantage in close-coupling the controller to the plant, since the process lag will generally outweigh the transmission lags. In these cases the controller can then be placed at the most suitable point such as behind the actual control panel.

With the electrical system, transmission lags are negligible in all cases and there is little point in exposing the electrical instruments to the conditions of the plant. The controllers would then be placed in standard electrical component racks behind the panel or even in a separate room. In

this system supervisory instruments as such are not necessary, since all the controller adjustments can be removed from the controller and placed on the panel with suitable miniature instruments displaying the measured and desired values and the valve position.

No reference has yet been made to the place of the recording function in the graphic panel. This is a subject upon which opinion is divided. The recorder is generally regarded as an instrument for the study of conditions *after* the event; it should not then require to be continuously observed and so should not form part of the control panel. Yet the recorder is useful, if not essential, for assessing operational efficiency, for analysing disturbances, and for setting the control actions when starting up the plant. It cannot be dispensed with, but should be placed in a fairly accessible position such as on a wing of the main panel. To economise in space, multi-point recorders of conventional design are used. The alternative view is that useful information about the development of a disturbance can be derived by observing the recorded *trend* of a controlled variable. In this case the recorder should be readily accessible and thus included on the main panel and, if possible, mounted in its proper position with regard to the measuring element on the plant. This can be catered for by the use of special supervisory instruments in which the measured value is continuously recorded on a strip chart. The other functions of the supervisory instrument, as detailed below, can be included if required.

Supervisory control instruments

From the previous discussion it will be apparent that the supervisory instrument is required to possess the following features:

(1) An indication of the measured value of the controlled variable.

(2) An indication of the desired value set on the controller, preferably displayed on the same scale as the measured value for ease of comparison.

(3) A means of changing the desired value set on the controller.

(4) A means of changing from automatic to manual control and *vice versa*, without causing a disturbance to the system.

(5) A means of manual regulation of the control valve.

(6) An indication of the position of the control valve for use when on manual control.

These are the process operator's tools with which the plant is to be run; they must then be conveniently located, easily accessible, easy to use, and reliable.

Pneumatic instruments of this kind are basically similar in design and operation. They consist essentially of two pressure gauge movements with a common scale, and the other at periphery. The second central pointer is a manually-set 'memory' pointer for indicating the desired value when on manual control. The change-over switch and pressure regulator are mounted concentrically within the unit case. This is simply a convenient arrangement; such a compact grouping is not essential and separate units can be used. The change-over switch has four positions indicated on the rim of the case: auto, seal, manual, and test. In the 'auto' position the gauge displays measured and desired values on the central and peripheral pointers, respectively. In the 'seal' position the controller output pressure is shown on the central pointer and the pressure regulator output on the peripheral one; changing to 'manual' restores the measured value back to the central pointer. In the fourth 'test' position the controller output pressure on the peripheral pointer can be compared to the valve pressure on the central pointer. It is thus possible to effect a smooth transfer in either direction.

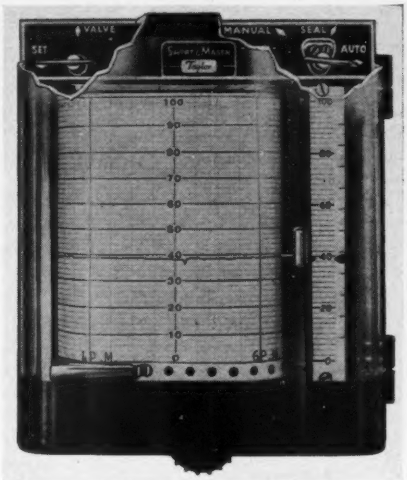


Fig. 3. 'Transet' recorder.

a pressure regulating valve, and a multi-position switch or switches for changing from automatic to manual control. One pressure gauge is permanently connected to the output of the transmitting unit and thus indicates (or records) the measured value of the controlled variable. The second pressure gauge is connected through the 'auto-manual' switch and indicates either the desired value pressure applied to the controller or the pressure applied to the control valve. The pressure regulator is used to supply the desired value pressure when on automatic control or the valve operating pressure when on manual control. Intermediate positions are provided on the 'auto-manual' switch at which the control valve is sealed off while the connections from the pressure regulator are changed over. This permits the regulator to be reset so that no movement of the control valve occurs when the change over is completed, *i.e.* a 'bumpless' transfer is ensured.

The connections between the controller and the supervisory instrument are illustrated in Fig. 1, in which the controller is shown close-coupled to the plant. It will be seen that four transmission lines are required between the plant and the panel, their use being as indicated in the diagram. The controller cut-out relay is required only when the controller is separated from the panel and is simply an air-operated valve in the controller output line which is not opened until the system is placed on automatic control. For panel-mounting the controller, only the usual two transmission lines are required, and the cut-out relay is also unnecessary since the controller output can be sealed by the 'auto-manual' switch, but this requires an extra connecting line between the controller and the supervisory instrument.

Two typical pneumatic instruments of this type are shown in Figs. 2 and 3. The Elliott instrument (Fig. 2) is indicating only the pressure gauge scale having two indicating pointers, one placed centrally

The Short & Mason instrument (Fig. 3) is the recording unit of the *Transet* series of instruments and combines all the functions previously described with a continuous record of the measured variable on a horizontally travelling strip chart. In this instrument the left-hand pointer carrying the recording pen is permanently connected to the measured value pressure gauge; the right-hand pointer indicates the desired value, or the control valve pressure as determined by the two change-over switches at the top of the instrument. The pressure regulator adjustment projects below the bottom of the case.

Types of graphic panel

The selection of a graphic panel rather than one of conventional design must be considered in conjunction with the design and operation of the process. It is not suggested that the graphic panel will be of great value in any but a relatively small number of cases. It is only on large and complicated processes that it may be useful and at the moment insufficient practical experience is available to make any firm recommendations. Assuming, however, that for certain processes at least, some form of graphic presentation is advantageous, then the following characteristics will be required:

(1) A simple and easy to read schematic flow diagram of the process with the instruments mounted in positions that allow rapid assessment of the operating conditions by both the operating and supervisory staff.

(2) An easier and more efficient method of control and operation than is presented by the conventional type of panel.

(3) A clean and bright appearance to assist in the reduction of operator fatigue.

There are basically two types of graphic

presentation, which have been termed the full-graphic and the part-graphic panels, and also two different types of construction, the conventional flat upright panel and the console or desk panel.

The full-graphic panel. This may be regarded as the complete and logical development from the conventional type. The instruments used are entirely of the supervisory type described previously and are all directly mounted into the flow diagram. The recorders are either positionally mounted or displayed on adjacent wings. The major advantage is the full space flow diagram with all the essential information and adjustments displayed at the appropriate points. As an upright panel it will generally be some 20 to 30% shorter in length than the conventional.

The part-graphic panel. As the name implies this type of graphic presentation is part way between the conventional instrument panel and the full-graphic type. The panel has a relatively smaller flow diagram and the only instruments positionally mounted are small indicators, generally of the duplex type indicating measured and desired values. The major instruments, *i.e.* those requiring manual adjustments by the operators, are mounted *below* the flow diagram in the most accessible position. If their number is limited it is possible to use conventional instruments, but generally a more compact type such as the supervisory instruments would be used, thus permitting a more compact arrangement and increasing the efficiency and ease of operation. The major disadvantage is the non-positional mounting of the operational instruments; even if these are 'keyed' to the diagram by suitable symbols the system is not quite so easy to 'read' as the full-graphic. On the other hand, it is claimed that the more compact arrangement of the bulky operational instruments permits the length of the panel to be reduced still further.

Panels of either of these basic types can be constructed as flat, upright panels or as consoles. The flat, upright panel is unlimited in length and is thus most suitable for the overall operation of the complete process, especially where the process is large. There is, of course, the danger that the conditions of the large conventional panel will be reproduced and the operating efficiency will be impaired.

The console type of panel is designed for use on individual plant units rather than for a complete process, unless the process is rather small. The console control desk is not a new idea, it has been used frequently in electrical applications, and rather more infrequently in the process industries, *e.g.* as a reading station for multi-point indicators. The console serves a rather similar function to the console organ from which the name is derived. Briefly, all the necessary adjustments are placed within easy reach of an operator seated at the desk. The primary information for control is displayed on the graphic panel which slopes up from the front of the desk, and the secondary information, records and non-essentials, are displayed on the wings built out from the desk, which can, however, be seen by the operator without his leaving his seat. In this case the size of the panel is limited to, say, some 8 to 10 ft. in length and 2 to 3 ft. in height. This does limit the size of process which can be controlled, but in itself this may not be a disadvantage, since it defines the limits of the operator's responsibilities. On a large process a number of such consoles would be required, each with its own operator and relating to particular sections of the plant, but situated in the same control room. The integration of these separate units might prove difficult, but the possibility of an over-riding supervisory control from an additional console to co-ordinate the whole process has been suggested.

The graphic panel of the console may be either full- or part-graphic in layout; an example of each type is shown in Figs. 4 and 5. Fig. 4 is an Elliott supervisory console designed for the new Isle of Grain oil refinery. The supervisory instruments are of the pneumatic type illustrated in Fig. 2 and are positionally mounted in the flow diagram. The recorders are the standard *Elliottronic* potentiometers using an electro-pneumatic converter to produce the necessary input signals. The controllers are Elliott *Trimode* units installed in racks in the body of the console desk, although field-mounting could be used if required.

The console shown in Fig. 5 is the Evershed & Vignoles *Centroller*, which uses entirely electrical operation. The panel in this case is of the part-graphic type and contains 36 miniature indicators positionally mounted for indication of plant conditions. Some are of duplex action for comparison with the desired value where automatic control is being used. Below the diagram are the small sub-panels of the 19 controllers included in the unit. These display on the indicator the position of the control valve, below which are the desired value and manual controls with the change-over switches. Above, and provided with a sliding cover which can be locked against unauthorised adjustments, are the controller action settings.

The controller units are again mounted in the body of the unit, in this case field mounting is not necessary.

In the original designs of line diagram and graphic panels the flow lines and plant equipment were painted on the panel. A more recent development which presents a better appearance and permits greater flexibility is the use of metal or plastic shapes for the plant vessels which are mounted in relief on the panel. The flow lines are similarly metal or plastic strips colour-coded to suit the particular application.

Conclusions

Undoubtedly the major advantage of the graphic presentation is the clearer representation of the part which the instruments play in measurement and control. It is often claimed that a good operator does not need assistance of this nature, since he should know the position and purpose of every instrument and the flow diagram is, in fact, redundant. However, this is an ideal state of affairs and it does not allow for such possibilities as the impairment of faculties by the fatigue of long shifts, particularly the ever-blamed night shift. The presentation of the process by graphic means cannot be other than beneficial to the operator, no matter how skilful. Furthermore, it makes possible the quicker perception of errors and the speedy application of corrective action. Its place in the training of new staff must also be borne in mind.

Economically, it is doubtful if a very good case can be made out for the graphic panel. Reductions in cost of the order of 20 to 30% have been quoted in comparison with equivalent conventional panels, but these figures refer to refinery installations which are probably exceptional. If the extra cost of transmission lines is included, then the graphic panel may very well cost more than the conventional one. Almost the only appreciable saving which can be guaranteed is that due to the reduction in the size of the control panel.

The standardisation of instruments permitted by the supervisory method of control is obviously an important factor. Interchange of units greatly facilitates maintenance and it is interesting to note that the console units are supplied with

Fig. 4. Supervisory control console.

Fig. 5. 'Centroller' control console.

a spare controller which can be used to replace *any* faulty unit irrespective of the nature of the variable being controlled.

Apart from its cost, the graphic panel is criticised because, it is alleged, it lacks flexibility. Furthermore, it is argued, the control mechanisms are scattered over a wide area of the plant and even if placed in the control room, their adjustments are not readily available. The decentralisation of the control units is greatly outweighed by the benefits gained by close-coupling the units to the plant and, although their initial adjustments may certainly be troublesome, these should rarely be changed once the optimum settings are found. The argument of inflexibility is a common one, yet is hardly logical when the graphic is compared with the conventional panel. A change in the nature of the controlled variable is, in fact, a good deal simpler since the units are all standardised and the inclusion of additional instruments requires much smaller cut-outs, although it would probably be difficult to fit these in with the flow diagram. Extensive changes in the plant flow system would naturally present a problem which is not encountered with the conventional panel. But extensive changes in layout are not common, and minor changes such as do frequently occur are easily accommodated by the use of the detachable metal or plastic beading to represent the flow lines on the panel.

The opinion has recently been expressed that the initial enthusiasm for the graphic panel, which was exhibited particularly in America, is now on the wane, and that the method of graphic presentation is being relegated to its proper position as only one means of improving operational efficiency. This may very well be the case; the graphic panel is certainly limited in application and is not necessary in the great majority of cases. But there are obviously many large and complex processes where a graphic presentation of the operational controls cannot be other than of value to the operators. However, until greater experience in the use of such panels has been obtained, the issue cannot be fairly judged.

There remains the possibility of the use of supervisory instruments without the graphic presentation. In such cases the size and complexity of the process do not affect the argument. The two advantages which can be gained are an improvement in the quality of control by the use of close-coupled circuits, and a decided reduction in the size of control panel. There can be no objection to this method of use, so long as the temptation to use conventional presentation is firmly resisted. In other words, the instruments should not be packed tightly on the panel; a sense of proportion must be maintained, since nothing could be more soul-destroying to the operator than a panel tightly packed with pressure gauges! A reasonable spacing must be employed, possibly with conventional instruments such as recorders or controllers. A console panel, intended for the Billingham Division of I.C.I. Ltd., and using supervisory instruments in this way, has recently been illustrated and would appear to be an eminently practical proposition.

To sum up, the graphic panel and the supervisory instruments represent a distinct break from conventional practice. Nevertheless, the fact that standard equipment with a high degree of interchangeability and flexibility in use is already in production is a tribute to those manufacturers who have contributed to the development of the system. It is to be hoped that the user industries will take the fullest advantage of these developments.

Production of continuous sheet mica

Development work in the processing of mica into continuous sheets for electrical insulation, which started in France during the German occupation, has culminated in the U.S.A. in improved economical methods for forming sheets of mica, using conventional paper-making equipment.

The raw material consists of muscovite mica in the form of domestic and mine waste, scrap or recovered mica. The manufacture of the sheets is similar to the manufacture of paper from wood pulp.

In an article in *Electrical Engineering*, May 1952, it is stated that the mica is prepared by being partially hydrated by heating. Immediately after leaving the furnace, the hot mica is placed in a saturated solution of sodium carbonate or bicarbonate. This removes the swelling between the layers of the mica. The mass is then allowed to cool. At this stage the thin layers scarcely adhere to each other. Still containing a large amount of the alkaline solution, it has to be drained, and is then immersed in a strong solution of hydrochloric acid or sulphuric acid, which causes it to puff to as much as a hundred times its original thickness. At this point, the layers of mica are so loose that only washing and agitation are required to reduce the mica to a pulp.

The pulp is now ready to be made into a continuous sheet. It can be made on a Fourdrinier machine, the conventional mechanism used in paper-making. As the sheet comes from the machine it has about half the density of natural mica because of the air between the layers. The tensile strength depends on the source of the mica and the type of treatment it has received. Before it can be used, a binding agent must be applied. This is achieved either by spraying or dip-coating.

As an example of the versatility of mica made by this method, it is of interest to note that it has been used as a component in silicone-moulding plates, while its homogenity and uniformity make it suitable for such purposes as the manufacture of commutator segment plates, and for various types.

Crushing rolls. When a finer reduction of a product is required than that given by a crusher, crushing rolls can be usefully employed as they crush the product into granular form and not into flour. Sturtevant Engineering Co. Ltd. describe their range of crushing rolls in their publication 9201, giving sizes of the rolls, charts for approximate outputs and specifications.

DISTILLATION

Calculations and theory; batch, azeotropic and extractive distillation; packed columns; bubble cap plates

By H. H. M. Jones, B.Sc.Tech., A.M.I.Chem.E.

THERE seems to have been less published information on the unit process of fractionation in the past year compared with previous years covered by these reviews. However, the scope of the work described is somewhat wider than usual and, if the mathematicians have been analysing multicomponent rectification as often as in the past, there has been also a renewal of interest in bubble plate efficiency. It is a disappointment to note a decline, temporary it is hoped, in the number of papers on batch, azeotropic and extractive distillation.

There has been a noticeable absence of new textbooks on the subject or new editions of standard works, but as there was a flood of such volumes a year or so ago this is hardly unexpected.

One quite interesting exception has been the publication of 'A Source Book of Technical Literature on Fractional Distillation,' by Gulf Research & Development Co.[1] This is a convenient collation of the most important papers of the past 50 years, beginning with Lord Rayleigh's 'On the Distillation of Binary Mixtures' and ending with Edmister's recent comprehensive review. The criticism that some of the fundamental European contributions have not been included should not obscure the fact that between the covers of this volume can be found those papers which, unfortunately, could otherwise be studied in very few reference libraries. The publishers deserve congratulation.

It is again convenient to consider separately the new work reported in each section of the unit process.

Calculations and theory

Although there have been papers on the mathematical analysis of the phenomenon of fractionation, there is a tendency for some of this effort to be directed to rapid and reliable prediction of vapour/liquid equilibrium for those cases where these basic data are not available or alternatively where some check is needed for experimental figures. It is hoped that this trend will continue since it is clear that in this sphere the analytical approach will not be restricted by or to those systems where ideality obtains as is still often the case with mathematical treatment of the separation process itself.

A formula relating vapour and liquid compositions is suggested by Prahl[2] who puts forward a new method for the presentation of vapour/liquid equilibrium data. The formula involves three constants derived by a graphical procedure. It is claimed that the method helps in the rapid determination of the theoretical plates for a given separation as well as being used for interpolation and extrapolation of experimental curves.

Farrar[3] in an introduction to the fundamental relations for analysing fractionation performance shows how Raoult's and Henry's laws can be used for the calculation of vapour/liquid equilibrium in multicomponent systems. He limits his exposition to hydrocarbons and gives examples in fractionation and adsorption.

In a series of papers Herata [4, 5, 6, 7] considers the determination of vapour/liquid equilibrium data by starting from the classical Duhem equation. Like Margules and Van Laar, he puts forward a method of integration of the equation, this time by a stepwise procedure. The calculation of equilibrium from vapour pressure data which this makes possible is extended in the second paper by assuming that the curve can be represented approximately on a logarithmic paper by three straight lines which can be represented in turn by a general equation. In the third paper another approach to the prediction of binary equilibrium data is based on boiling point curves. A differential equation derived from thermodynamic considerations and corresponding to the Duhem equation for isothermal equilibrium is involved. Constants characteristic of each system are introduced and the equation solved by the method of the first paper. The last paper is a discussion of the effect of pressure on equilibrium relationships.

Equations derived by Wohl[8] represent the activity coefficients in the liquid phase of binary mixtures and Kobe and Van Rosenberg[9] have tested them with the first five normal paraffin isomers and isobutane. Conditions above and below critical points are considered; the errors introduced by this analytical procedure are too small to affect engineering calculations.

A method of Bowman[10] should prove useful for the expeditious determination of true boiling point curves from simple distillation data. Formulæ are derived for T.B.P. and volatility curves by a method previously described[11] and some examples are given. The importance of avoiding if possible the somewhat elaborate procedure of T.B.P. curve determination makes this a valuable paper.

In the better investigated field of column calculations, there have been several different approaches. Hutchinson[12] has concluded his series of papers on the use of printed forms to relieve the tedium of computation of multicomponent separation. This approach has been noted before and it will be sufficient to add that the last article is devoted to column sizing.

An ingenious adaptation of the McCabe-Thiele diagram by Beychok[13] makes possible an analytical solution for the separation of an ideal binary mixture. It involves a shift of co-ordinates as does the method of Smoker[14] which it resembles in some ways. However, it has the advantage of the earlier solution in that the algebraic equation giving the plate requirement is simpler to apply. It has proved useful to its author as a rapid check on plate efficiencies in experimental work.

A method of calculation based on an analytical procedure is put forward by Krylov[15] who derives an equation analogous to that of Harbert.[16] The number of plates in a binary separation under any given condition can be computed as long as the mixture is ideal. The application is therefore definitely limited. Florin intends to consider this special case among more general ones in a series of papers concerned with the mathematical treatment of rectification of ideal multicomponent mixtures of polar substances. An ideal mixture is defined here as one the constants of which can be plotted on the Florin diagram.[17] In the first paper[18] this procedure and the fundamental relations for the representation of vapour/liquid equilibrium for multicomponent mixtures are explained. Instead of attempting to modify the accepted definition of ideality, Sorgato[19] introduces the concept of pseudo-volatility; this function and the simplified determination of other parameters permits rapid calculation of the number of stages necessary for a certain separation. The method can be used graphically.

The problem of pressure drop across plates and its effect on vapour/liquid equilibrium is important when calculating the stages required for a vacuum fractionation. Eshaya[20] has studied this problem and proposes a means of establishing the equilibrium curve which is corrected for pressure variation. It is assumed that the pressure drop is proportional to the length of the column and that the latter has a uniform efficiency.

White has concluded a long series of papers[21-29] which provides an excellent digest of the problems and applications of fractionation on an industrial scale as well as a summary of practical design methods. The first paper deals with the basic physical principles, the second and third with column calculations for binary mixtures, both graphical and analytical methods; the fourth with special problems of binary separation, *e.g.* low-temperature distillation, multiple feed and side streams; the fifth and sixth with bubble plate hydraulics and design; the last three with the various aspects of column design for ternary mixture separation. The latter are useful, as there has been little if any work published on this aspect in the past few years.

In the less exact sphere of equilibrium flash calculations Reilly[30] offers a direct solution and reduces considerably the trial and error involved. This is done by the use of constants which are given in the paper.

The use of automatic calculators to accelerate the resolution of the complex mathematical problems associated with an accurate evaluation of fractionation is increasingly reported. Opler and Heitz[31] modify the Thiele and Geddes and Lewis and Matheson procedures to enable plate-to-plate calculations to be made on a punched-card machine. Donnell and Turbin[32] have a tabular method for the solution of multicomponent separation problems which can also be adapted for a similar machine. Rose was the pioneer in this method of calculation as has been previously noted in these reviews and now with his co-workers[33] describes the use of another mechanical device, this time a digital computer, to perform automatically the trial and error of the choice of a proper reflux ratio for binary fractionation.

Franklin *et al.*[34] describe a mechanical analogue for the solution of fractionation problems. The separation is represented by an equivalent mechanical process rather than by a series of mathematical equations. The flow streams of liquid and vapour are represented in quantity and composition by an equivalent interchange of steel balls between the mechanical stages. For the present it seems that this machine will be more useful as a clear demonstration of the mass transfer process for teaching purposes.

Laboratory investigation and basic data

Work in this field can be conveniently divided into that concerned with the design of apparatus and that concerned with experimental results.

An improved still for the determination of vapour/liquid equilibrium is described by Altsheler *et al.*,[35] the main feature being a means of obtaining samples quickly and with a minimum of error. Othmer *et al.*[36] have developed a recirculating equilibrium still which, it is claimed, can be used to obtain flash vaporisation curves at sub-atmospheric pressures.

The design of laboratory apparatus to simulate industrial practice as far as possible and yet be primarily a research tool was the intention of De Porto and Scrocco.[37] They describe a plate column made of glass, the plate efficiency being 60 to 70% for the experiments reported. Wilcox *et al.*[38] were more concerned with reproducing the advantages of continuous fractionation in the laboratory. This is sometimes difficult to achieve because of the need for accurate control of very small flows. A rather elaborate solenoid-operated valve is suggested to overcome this and a full discussion ensues on the technique of operation of continuous laboratory stills. Highet[39] also has devised a method of operational control with this type of apparatus. It is based on maintaining a constant ratio between flows of feed and distillate and a constant back pressure across the column which is hardly different from the large-scale method. The column was packed with stainless-steel gauze and used for a variety of duties.

Raper[40] describes a laboratory apparatus embodying all the components necessary for carrying out heterogeneous fractionation, while Thornton[41] reports the design and construction of an equilibrium still for the determination of extractive distillation data.

Details of apparatus construction are noted by Crook and Datta[42] and Simpson and Sutherland,[43] who all give method of collecting products from laboratory distillation with a minimum of disturbance to the operation. Both systems involve a multiplicity of receivers. A combined still head and reflux meter is proposed by Collins and Willcock,[44] while Massingham[45] uses resistance wires cemented with corrugated lagging as a cheap means of heating small still kettles.

Two Australian papers[46, 47] contributed by Smith and Hume, respectively, contain descriptions of stills utilising glass helices and in the second paper results are given for the separation of higher aliphatic alcohols.

The efficiency of laboratory columns is always estimated by their ability to separate a standard test mixture and Haldenwanger[48] draws attention to the requirements that these mixtures should meet, pointing out the differences for the evaluation of a large number of plates, vacuum operation, etc.

The amount of basic data on vapour/liquid equilibrium of mixtures has been augmented by data reported on many new systems. Among the more interesting are the study of the effect of various salts on ethanol water equilibrium due to Tursi and Thompson[49] and Jost,[50] and butane and hydrogen by Aroyan and Katz.[51] A list of 59 systems, both binary and ternary, is given by Walsh,[52] to which may be added acetonitrile and ethylene dichloride by Price and Hickman[53] and 2-methyl furane and methanol by Hickman and Hall.[54]

Herington[55] proposes a test for the consistency of experimental isobaric vapour/liquid equilibrium data; allowances are made for non-ideality and the method is applied to 24 systems previously reported.

Batch distillation

Several recent papers contribute towards a better understanding of the changes during batch fractionation. Rose and his co-workers have been responsible for two papers[56, 57]; in the first of these a theoretical comparison of batch and continuous distillation is made; it is demonstrated that when column hold-up is negligible both methods give similar results, but if it is appreciable, and particularly if combined with an initial low proportion of volatile component, then batch working has advantages. In the second paper the application of punched-card calculators to the solution of batch distillation problems where simplifying assumptions do not apply is described.

The effect of hold-up on sharpness of separation has also been studied by Pigford *et al.*[58] A wide range of hold up in plate columns is considered from 10 to 60% of the kettle charge; the approach is mathematical and a differential analyser is used in the resolution of equations. It was found that the optimum value of hold-up was roughly that encountered in industrial practice.

The effect of pressure and hold-up in the operation of batch columns was investigated by Hawkins and Brent,[59] who found that the change in pressure and its influence was dependent on the amount of charge distilled.

Bragg *et al.*[60] have been granted a patent for the control of industrial batch stills.

Azeotropic and extractive distillation

Melkerson[61] reviews the present state of knowledge of this branch of the subject and gives a long list of references. Chambers[62] devotes himself to the fundamental principles and illustrates these with the use of furfural as an extractive solvent.

In another paper[63] the same author makes a new approach to extractive distillation. The column is conceived as being of two sections with the extractant flowing countercurrent to the first key in one section and co-current with the second key in the other. The extractant may be of any volatility relative to the keys and it may form an azeotrope with one or both. The only restriction is that any azeotrope

shall be easily broken or be a product itself. The method is novel, but may be too generalised for immediate application.

Neumann[64] presents a graphical treatment for the special but industrially common case of the rectification of a partially miscible binary mixture having the azeotropic point in the non-miscible region. Such mixtures are butanol and water and furfural and water and a two-column arrangement is used in their separation. The heterogeneous azeotrope is resolved by separation of combined head-streams from both columns into two layers in a decanter. Equations are deduced from operating diagrams and fixing the 'cut-point'; the significance of the latter in the calculation of columns is discussed. The load on both columns and its relation to number of plates, steam consumption and to conditions governing the feed, reflux and distillate are discussed. This paper is of some practical significance.

In the field of azeotropic distillation Frank[65] considers its importance in coal tar processing. Because coal tar is largely aromatic in character, there is little tendency for azeotropes to form, but the principle can be successfully applied to the separation of predistilled fractions consisting of a small number of components of narrow boiling range. The example of indole from diphenyl in indole oil using diethylene glycol as an entrainer is quoted. Mention could also have been made of a successful process based on azeotropic principles for the removal of paraffins from toluene using a mixed entrainer.[66]

Berti and Bottighia[67] report laboratory work covering the extraction and purification of aromatic hydrocarbons from petroleum cuts, with particular reference to azeotropic distillation. Applications to industrial practice are then discussed. The entrainer was methyl cyanide and it is suggested that the methods employed can easily be extended to the fractions arising from aromatisation, hydroforming, etc., as well as to light aromatic distillates of coal carbonisation.

Harrison[68] claims that benzene may be separated from cyclohexane by the distillation of the latter as a ternary azeotrope with water and *n*-propanol, the azeotrope being washed with water to recover the hydrocarbon.

The selection of a suitable solvent for the separation of binary mixtures is facilitated by an empirical equation deduced by Garner and Ellis,[69] based on accurate boiling point determinations of the two components in a range of solvents. The authors also describe a method of linear interpolation between the binary activity coefficient concentration diagrams to predict ternary vapour/liquid equilibrium data. It is claimed that this gives closer agreement with experimental results than the more usual equations.

Packed columns

Many investigations are reported on the fractionating efficiency of different packings, some of which have not been completely evaluated hitherto and their effectiveness is now compared with the more conventional types.

Myles *et al.*[70] report that experiments with Berl saddles, single and triple turn helices, glass spheres and a commercial Heligrid filling all in a column 3 ft. long and 25 mm. diameter. Two test mixtures were used, the usual methyl cyclohexane and *n*-heptane for atmospheric work and *n*-dodecane and cyclohexyl cyclopentane for low-pressure distillation. Packing efficiency column hold-up and throughput were determined at various boil-up rates and pressures from 20 mm. to atmospheric. From the data presented it is clear that for loose packings the column should be operated at close to maximum capacity. Over the whole range of operation the fixed grid packing had the best characteristics, while the spheres had the lowest efficiency. All the packings operated best at 150 to 200 mm. absolute pressure. Reynolds and Sugimura[71] gave results on two columns with Heligrid packing and compared these with the results for glass helices, stoneware saddles and rings. Again the Heligrid was the most efficient though deviation of the test mixture, methyl cyclohexane and 2.2.4 trimethylpentane, from ideality was sufficient to have a considerable effect on calculated H.E.T.P. Herlin *et al.*[72] carried out experiments with protruded metal and MacMahon packings in three small-diameter columns; efficiencies were determined over wide operating ranges. Hold-up was largest for liquids of the lowest density and the flooding velocity highest for the heaviest liquid.

Packed columns find their industrial application in some measure due to their low-pressure drop and Barth[73] derives an equation from which this characteristic can be calculated with reasonable accuracy. Variation in packing is allowed for by the introduction of factors derived experimentally.

Work by Lerner and Grove[74] led them to put forward a new theory on the mechanism of loading and flooding of packed columns operating with countercurrent liquid/gas flow. Investigation on vapour/liquid equilibrium data for *n*-decane-transdecalin[75] involved the determination of the efficiency of the packing and the pressure drop in relation to the liquid loading. Hawkins and Brent,[59] however, devoted their activities to the evaluation of packing efficiency at reduced pressures. The system, ethyl benzene/chlorobenzene, was used and no significant difference in column performance was noted at the reduced pressures when the kettle composition varied for a fixed volume of charge. However, under all conditions the column performance varied inversely with the rate of distillation.

In the use of new packings Hickman[76] strikes a prosaic note when he describes a laboratory column packed with household cleaning sponge equivalent to ten theoretical plates.

Fuchs[77] examined the influence of the surface of tower packings on rectification. This new approach to the problem is a consequence of earlier work.[78] He reports that the use of a material having a porous structure may result in a lower H.E.T.P. due to selective adsorption of one of the components. It is claimed that published data in the effect of various packings can be explained on this basis.

In the industrial sphere, Morton[79] gives details of the operation of Stedman packed columns in the separation of petroleum distillates. Included in the paper are pilot-plant results for the packing, including the effect of pressure, diameter and height of column.

Industrial developments

The number of papers devoted to the operation of large-scale equipment appears to cover rather a wider field than in recent years.

Barnhardt,[80] after a year spent in the Seagram distilleries in the U.S.A., has written an informative report on the manufacture of beverage alcohol. This contains considerably more operational and plant detail than is normally found in general articles of this nature and in the information given on the distillation plant it contrasts favourably with the brief description by Acker[81] of a fatty acid plant recently erected in Canada.

Reismann[82] reviews the current practice in the U.S.A. in the vacuum distillation of petroleum fractions. Kohler[83] covers the present German practice for the distillation of coal tar and the methods whereby cuts to different specifications are obtained. This paper is interesting also for the information it contains on tube still design which normally is available only as applicable to the petroleum industry. Both papers are excellent surveys of their subjects. Benedict[84] is somewhat more specific in describing in detail three operational procedures for vacuum stills in petroleum working, giving pressures, temperatures flow rates, etc., for certain product specifications.

In two articles Dummett[85, 86] outlines his views on the proper selection and operation of fractionation plant; his remarks are directed to the operator rather than the designer. The basic principles of batch and continuous operation are described and important factors, *e.g.* vapour velocity, pressure drop, plate efficiency and stability, are discussed and assessed.

In the patent field there have been the easily removable trays of Ryart[87] which makes possible quick maintenance, the safety device of Engel and Hufnagel[88] to prevent the explosion of accumulated acetylene in liquid air columns and the inclined column of Smith.[89, 90] The last is specifically intended for viscous liquids; it is rotatable and packed with a perforated spiral of rolled sheet metal.

Bubble cap plates

A number of papers deal with this essentially practical subject. Those investigators who conduct experiments with industrial-size equipment, even if only a single bubble cap, make a particularly valuable contribution with their data.

Kirschbaum[91] carried out a long series of experiments with caps of different sizes in a column 750 mm. diameter and 200 mm. plate spacing; the maximum allowable vapour velocity is deduced and a relationship given enabling it to be calculated. The point to be noted is that the equation takes into account the ratio of empty tower cross-section to total bubble cap circumference. Data presented for the ethyl alcohol/water system give optimum cap diameter.

Pressure drop through bubble caps has been investigated by Huitt and Huntingdon.[92, 93, 94] Each contributory factor is examined separately and experimentally. Equations are developed and these can also be used for analysing problems of thermal functioning of bubble caps and trays.

Chu *et al.*[95] follow up the vigorous approach to bubble plate efficiency given by Chu and reported in the last review, with an empirical equation for estimating overall plate efficiencies of commercial columns. Reflux ratio and effective slot submergence are included in the equation, but it is only valid for liquid/vapour ratio between 0.4 and 0.8 and a submergence of not greater than 1.5 in.

That a certain amount of entrainment improves the overall efficiency of a column is well known. The paradox of a column being conceivably more efficient with half its plates removed is explained by the beneficial effect of increased height for transfer between droplets and rising vapour. Entrainment in a perforated plate column has been considered by Kamei *et al.* in two papers.[96, 97] The conventional method of entrainment analysis by the use of a salt solution on one plate was used. The amount of entrainment was found to be intimately connected with frothing phenomena and that a correlation should include vapour velocity, plate spacings and froth height rather than be limited to plate spacing only. In the second paper the experimental data are applied to examples and the effects of entrainment on plate efficiency are discussed.

The more fundamental factor of mass transfer rate is examined by Gerster *et al.*[98, 99] Gas and liquid film efficiencies are seen to be related to foam height and foam density. Correlations are given permitting the prediction of changes in gas and liquid rates upon plate performance. The second paper underlines the importance of separating the component efficiencies for purposes of prediction and extension of experimental data.

Schlatterer[100] takes the case of liquid air fractionation and considers plate efficiency from the point of view of a theory put forward by Kirschbaum[101] which states that efficiency is a function of the concentration of the binary mixture on a plate and the temperature difference between liquid and vapour. Plate efficiencies in the upper and lower columns of an air separation assembly could be explained fairly fully by this hypothesis, which may be extended to include ternary mixtures.

It is interesting to note that the first project selected for investigation by the Research Committee of the American Institute of Chemical Engineers is bubble plate efficiency. The programme is outlined by the chairman of the committee[102] and it is evident that, as he says, " This will be the first time that such a comprehensive study has been undertaken in chemical engineering." Its results will be awaited with great interest.

Miscellaneous aspects

In a new type of distillation column described by Rollet,[103] the reflux liquid is heated to its boiling point while the vapours immediately above are cooled. Increased efficiency is claimed.

A new rotary concentric tube column having a very high efficiency has been developed by Willingham *et al.*[104] of the National Bureau of Standards. It has a high throughput for equipment of this type (up to 4 l./hr.) and operates at 400 r.p.m. Murray[105] also has information on a spinning band column having rotating devices to which are attached strips of gauze. The apparatus has been used at pressures below 2 mm. for the sharp separation of methyl esters of fatty acids and fatty alcohols.

The problem of heat economy in industrial fractionation is a subject not often considered, but Dressel[106] reviews at some length the applications of the heat pump in this context. Performance figures and operating data for the separation of binary mixtures with the aid of a heat pump are given. On the basis of examples a diagram is developed from which a comparison of the economy of a fractionation with and without the machine can be made. Freshwater[107] reviews the various arrangements which have been suggested for the reduction of heat consumption and demonstrates how far these are still from achieving the theoretical minimum.

Storrow and Chari[108] carried out a series of experiments in a wetted wall column to determine the individual film resistance and their influence on H.T.U. values. The investigations were carried out over a wider composition range than previously, but lack of knowledge of such characteristics as diffusion coefficients in the liquid phase explained discrepancies in the correlations.

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The Design and Layout of Radiochemical Laboratories

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Although the handling of large quantities of radioactive materials such as is carried out at the major atomic energy plants frequently requires the use of elaborate and expensive laboratories and equipment, the employment of much smaller quantities for research applications does not necessarily entail such facilities. The substitution of glove boxes for normal fume cupboards and benches in particular can largely solve the problem at a fraction of the cost of conventional methods. This article reviews the design and layout of radiochemical laboratories with particular emphasis on this trend.

Contamination problems

A GOOD deal of information has been published on the general philosophy[1,2] and practical aspects of the design of new laboratories[3,4,5,6] and the conversion of existing ones[7,8] for use with radioactive materials. The object is, of course, to enable work with open sources to be done in such a manner that the spread of contamination is completely under control. This eliminates hazards both to the health of workers and to the results of experiments, in which a false count may ruin the value of a lengthy and costly investigation. Perusal of this literature might give a first impression that the application of radioactive isotopes inevitably involves luxurious accommodation and great expense. This is because much of it is concerned with the use of isotopes either in larger amounts or of more dangerous types than are frequently needed for research and development work. In fact, the accommodation need not necessarily be unduly elaborate, provided proper precautions are taken and the correct techniques followed.

One of the things which must be appreciated at the outset is that to work safely with radioactive isotopes more time and trouble must be taken than with ordinary inactive substances. It has been estimated that some operations, including the necessary 'dummy' runs and monitoring checks, require at least five times as many man-hours as would the same work with inactive materials.[9] The design of the laboratories should therefore be such as to reduce this extra time to a minimum.

The extent of the hazards obviously depends upon the nature and amount of activity involved, and some approximate classification is required before guidance can be given to users. Definitions of the various activity levels vary from author to author, but for the present purpose the use of $\beta\gamma$-emitters in such fields as academic, medical and industrial research may be divided into three levels:

'*Tracer*' *level*. Up to 10 μc. The presence of 1 μc. of some isotopes in the body is undesirable, but in normal use tracer quantities ought not to present a health hazard. Nevertheless, when it is remembered that 0.1% of 1 μc. is equivalent to 37 disintegrations per sec., it is obvious that care has to be taken not to spread contamination in such a way that counting is affected.

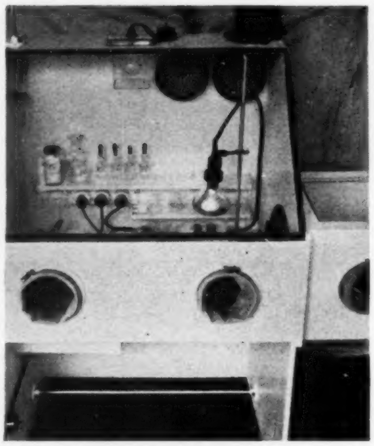

Fig. 1. Typical glove-box for work with α- and β-emitters.

"*Warm*" *level*. Ten μc. to 1 mc. These quantities present a possible hazard from ingestion and inhalation, as well as a correspondingly greater contamination risk, but they have not reached the level where external total-body irradiation has to be considered as a serious factor.

'*Semi-hot*' *level*. One to 100 mc. Potential hazards exist from ingestion and inhalation, contamination and also direct penetrating radiation, the last necessitating the provision of adequate shielding.

It is worth noting that when the more dangerous long-lived α-emitting substances are involved, the precautions to be taken against ingestion and inhalation of minute amounts have to be even more strict, although the danger from external irradiation does not arise in this case and does not therefore have to be considered.

General design considerations

It follows that if the contamination danger is eliminated, the health risk from normal operations with open sources is largely covered. For this reason the following general recommendations are of use, whatever the level, in minimising these hazards.

Radioactive work should be done in a special laboratory with a separate counting room, shielded if necessary, and a separate office. It is desirable that work in any laboratory be confined to one level of activity, as this reduces the chance of the odd one part in a million appearing in the wrong place and spoiling an experiment. It has been found that more trouble is caused by carelessness with small amounts of activity than by carefully planned and controlled work in proper conditions with much larger quantities.

Washing and monitoring facilities appropriate to the degree of potential contamination should be an integral part of the design. If the laboratory is being newly built or extensively reconstructed, it may be useful to make it adaptable for changes in dimensions and shape, and a form of panelling in plywood faced with stainless steel has been described:[10] stainless steel is unnecessarily elaborate, certainly for laboratories below the genuinely 'hot' (*i.e.* curie) level, but the principle can be applied to other materials without difficulty and at less cost.

The design should allow the restriction of activity to zones, and the active area should contain a minimum of furniture, books and non-essential apparatus. Swing doors, push-taps, etc., should be fitted to minimise the number of handles which have to be touched by occupants wearing gloves that may be contaminated.

Adequate floor space should be allowed, and 200 sq. ft. per man is not excessive. The floor should be of material which is easily cleaned, decontaminated and replaced if necessary, and in this respect waxed linoleum is satisfactory. Where mechanical strength is important, chemically-resistant tiles may be preferred. Untreated absorbent materials such as wood and concrete should be avoided, but chlorinated-rubber paint gives a reasonably serviceable finish to concrete floors.

The aim should be to have easily decontaminated finishes on all exposed surfaces,[11] and the use of materials with non-wetting properties has been advocated.[12] Phenol-formaldehyde, melamine and vinyl plastics, chlorinated-rubber paints and silicones have been found good from the point of view of resistance to general chemical attack and ease of decontamination after splashing with radioactive solutions. Walls should preferably have rounded corners and smooth surfaces and, if made of plaster, should be covered with a suitable hard, glossy paint. It is found in practice that surprisingly little activity gets on to the boundary walls of a laboratory, and hence strippable finishes are usually unnecessary.

Special requirements

"*Tracer*" *laboratories.* Here the special needs are very little beyond good ventilation and easily cleaned surfaces. Modern chemical laboratories require little modification provided they have adequate fume-cupboard accommodation. Good 'housekeeping' is essential, and the standard of cleanliness required may be compared to that in bacteriological laboratories.

'*Warm*' *laboratories.* The main feature when the millicurie level is reached is the potential danger from the spread of contamination. If this is serious due to the nature of the work or the isotope in use, the cheapest and most satisfactory way of reducing it is by conducting operations with open sources, whether in the solid or liquid state, in so-called 'dry-' or 'glove-boxes.' Experience shows that the elimination of orthodox techniques, the abandonment of normal fume cupboards and benches, and the substitution of glove-boxes can largely solve the problem at a fraction of the cost of the methods hitherto followed. One advantage is that the boxes, which are worked at a slightly sub-atmospheric pressure, require only a few changes of air per hour, and this small volume of air can be drawn through an individual filter chosen to be of such efficiency that the exhaust air does not present a problem of safe disposal. This requirement compares more than favourably with those for the usual fume-cupboard systems, where normal practice requires several fume cupboards per man, each with a generous air-flow to prevent escape of activity into the working atmosphere; not only may it be necessary for the consequent large volume of exhaust air to be filtered before release to the open air, but special arrangements, probably including preheating and a plenum system, are required for the incoming air which has to replace that extracted. Another advantage is that the exclusive use of glove-boxes renders the laboratory itself so free from contamination that safety precautions in the area may be greatly reduced. This means, among other things, the elimination of 'active' clothing with special laundry facilities, and a great reduction in monitoring services. It also follows that the cost of constructing the laboratory, apart from the provision of the glove-boxes, is little, if any, greater than that of a modern orthodox chemistry laboratory. The disadvantages are two-fold. First, there are the extra time and labour involved, although trained radiochemists accept this as one of the necessary features of their work. Secondly, there has so far been the lack of suitable glove-boxes and also of the requisite remote-control apparatus, although on the 'warm' scale this is relatively simple.

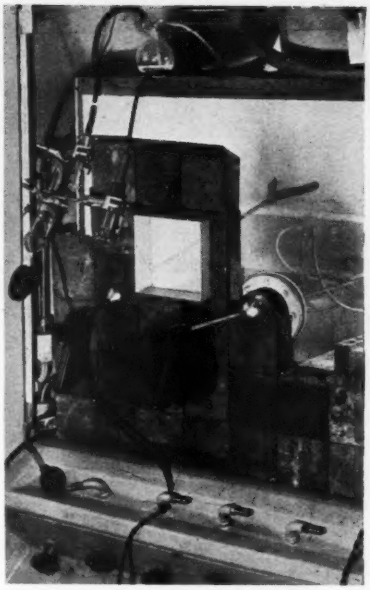

Fig. 2. Lead-shielded glove-box with remote-handling devices for γ-emitters.

The glove-box technique represents a trend of which advantage should be taken wherever possible, but its adoption is for various reasons as yet by no means complete or even extensive. It is therefore useful to summarise the essential requirements for working with more than tracer amounts of activity in more or less orthodox laboratories. If glove-boxes are not used, the provision of adequate fume-cupboard accommodation is the main requirement. All manipulative work above the microcurie level should be done in the fume cupboards, and hence the interior surfaces are liable to become contaminated. For this reason the design should be directed to minimising the spread and retention of contamination. Handling of open sources outside the fume cupboards should be reduced to a minimum, but steps should be taken to prevent contamination of the laboratory surfaces. Wooden benches should be polished to prevent activity from soaking in if splashes or spills occur. As an additional safeguard they may be covered either by metal trays lined with absorbent material, *e.g.* blotting paper, or by thin *Polythene* or metal sheet; alternatively, an effective expendable covering may be made of bituminised paper or of *Cellophane* sheet topped with ordinary brown paper.

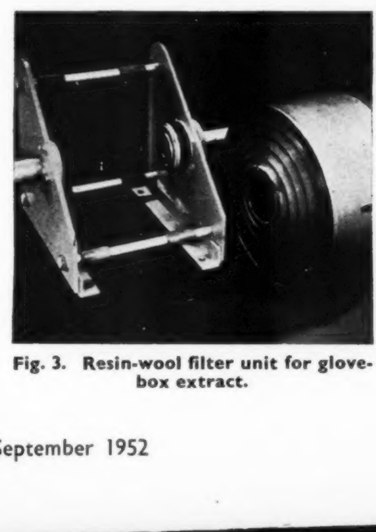

Fig. 3. Resin-wool filter unit for glove-box extract.

Laboratory services should as far as possible be enclosed to eliminate dust-retaining surfaces and to facilitate cleaning. Space should be provided in an area free of activity for storing monitoring apparatus, rubber gloves and protective clothing away from contamination risk. Automatic equipment such as piston-type pipettes, rubber-bulb wash-bottles, etc., should be within easy reach to remove the temptation to put things into the mouth. Similarly, remote-handling devices such as tongs to reduce hand exposure should be readily available.[13, 14]

'*Semi-hot*' *laboratories.* At this level the principal requirement additional to those for 'warm' laboratories is the provision of shielding from β- and γ-radiation. For 'pure' β-emitters this need not be massive and may conveniently be of glass or *Perspex*, but where γ-radiation is present the requirement becomes more exacting. It is most conveniently met by close shielding of the sources rather than by more extensive shielding of the individual. As much advantage as possible should be taken of the inverse square law, and the layout should permit the location of the bulk of the activity at a distance from the working and counting areas.

It has to be remembered also that shielding is frequently needed above and below the sources as well as on all sides, and this may involve a large mass of lead or other heavy material, hence the loading of the floor may have to be greater than usual. Where temporary lead walls are used, they should be of interlocking bricks to eliminate cracks whilst maintaining stability and ease of erection and dismantling.

The use of glove-boxes to confine activity becomes even more desirable. The boxes themselves may require heavy shielding, and remote-handling apparatus and techniques become more complicated.[15, 16, 17, 18]

Provision must be made, too, for the storage of residues, both solid and liquid, pending disposal or decay.[19, 20] Liquid effluent is most easily stored if kept concentrated, and every effort should be made to avoid unnecessary dilution. Active solutions and washings from contaminated apparatus are conveniently placed in bottles or carboys, and these may have to be

shielded. If activity cannot be kept concentrated in this manner it may be necessary to build external delay tanks. Where this is so, the expense may be kept down by taking the effluent from a selected sink or sinks to the delay tanks, whilst the inactive waste from the laboratory is run to the normal drains with, of course, adequate precautions to prevent activity in quantity from getting into the sewage system. Bins with foot-operated lids should be available for the easy disposal of handling-tissues and other contaminated solid waste.

Glove-boxes and accessories

The glove-box may be quite simple, and the actual size and design will depend very much on the operation to be performed. Plywood is a satisfactory material, finished inside with a strippable lacquer or a suitable hard, glossy paint. A window for viewing is conveniently made of glass or *Perspex*. Alternatively, the whole box may be made of *Perspex* sheet. The joints should be tight so that a slightly sub-atmospheric pressure of about 1 in. of water-gauge can be obtained inside without a high extract rate. The reduced pressure is maintained by means of a small pump, from which the filtered exhaust may be led into a normal fume-cupboard extract or to some other suitable outlet. Rubber gloves with long arms should be sealed into special ports in such a way that they can be changed without opening the box to the laboratory atmosphere. If necessary, provision should be made for the use of remote-handling devices; for 'warm' work these will normally be limited to such items as long-handled tongs, but at higher levels more complicated apparatus and lead shielding, including ball-and-socket joints and lead-glass windows, may have to be fitted.

The box itself should be portable so that it can stand on a bench, table or trestle with the appropriate services readily accessible, and also be easily removed for decontamination. It should be mounted at such a height that the operator can sit with his knees under the box. The glove-ports should be so placed that the arms are in the most comfortable working position. The technique can easily be very tiring, and if the glove-ports are placed fairly low the operator can obtain some relief by resting his upper arms on the ports and his elbows on the floor of the box. Typical views of boxes suitable for α and low-level $\beta\gamma$ work and for use with higher levels of α-, β- and γ-emitting isotopes[21] are shown in Figs. 1 and 2 respectively. Frequently the glove-box will be designed and built by the user for his particular requirement, but there is now commercially available a standard unshielded box suitable for work with α- and pure β-emitters and with small amounts of γ-emitters.

One of the essential features of glove-boxes is the side or 'posting' box to enable samples and apparatus to be inserted or taken out without opening up the main box. This consists of a small compartment, with air-locks, so constructed that it can be completely sealed off and removed. These side-boxes can also serve to connect two glove-boxes together, enabling samples to be transferred from one to the other without interconnecting the atmospheres. Details of an ingenious device using plastic bags for transporting active materials across such a contamination barrier have recently been published.[22]

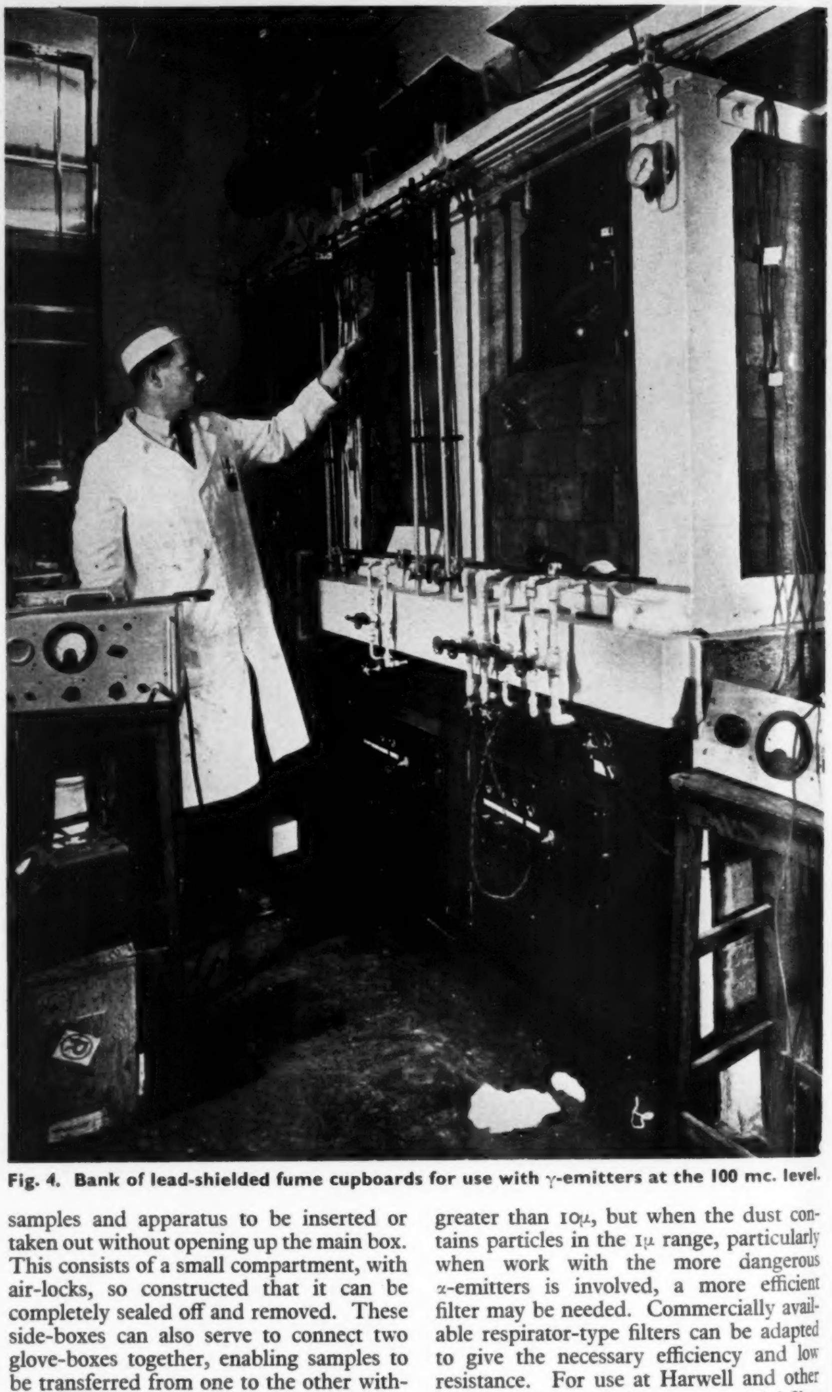

Fig. 4. Bank of lead-shielded fume cupboards for use with γ-emitters at the 100 mc. level.

The other essential is a suitable filter to decontaminate the extracted air. Where the airborne contamination is entirely particulate, a dry filter is sufficient. This may consist of a simple glass-wool or similar filter in cases where the aerosol is known to be of large particle size, say greater than 10μ, but when the dust contains particles in the 1μ range, particularly when work with the more dangerous α-emitters is involved, a more efficient filter may be needed. Commercially available respirator-type filters can be adapted to give the necessary efficiency and low resistance. For use at Harwell and other Government establishments, a special filter unit has been designed, which is efficient to better than 1 part in 10^7 for particles of all sizes, whilst at the same time offering a low resistance to the flow of air at the speeds required for glove-box operation. This unit, which can be easily and safely removed and replaced, is shown in Fig. 3.

Where gaseous activity is likely to be present in the extract air, the need may arise for suitable scrubbing towers or other more complicated filtering systems.

Fume cupboards

Fume cupboards which are to be used for work with radioactive materials should be designed with three objects in view, namely the minimum possibility of spreading contamination on to the surfaces, the maximum ease of removal of contamination if it is so spread, by accident or carelessness, and the elimination of a hazard to workers by the escape of radioactive materials or radiations into the laboratory.

To cover the first point, the provision of generous fume-cupboard accommodation to prevent crowding is essential. Three fume cupboards per man is not unreasonable. Techniques should be aimed at minimising the production of radioactive aerosols, and for this reason surface-radiation heaters should be used in preference to bunsen burners and hot-plates. The cupboards should be fitted with metal trays, lined with absorbent material, large enough to cover the whole base and to retain all the active solution present in the event of a spill. Controls to services should be brought outside and wherever possible operated on the elbow- or knee-push system.

To facilitate decontamination, it has frequently been recommended that fume cupboards should be constructed of stainless steel and finished internally with a strippable lacquer. Experience has shown, however, that for normal operations a conventional design, with the wooden surfaces coated with a resistant finish, such as a chlorinated-rubber paint or lacquer, is serviceable and comparatively easy to decontaminate.

Adequate draught should be provided to protect the people working in the laboratory, and the mechanical control of the exhaust system may be critical.[23] An airflow of the order of 100 linear ft./min. is desirable, and the efficiency of the draught should be checked by tests with a smoke generator. For many operations it is useful to cover the front of the fume cupboard with a *Perspex* sheet containing a number of portholes through which the arms can be inserted. By closing the ports not in use, the volume of air needed to maintain the necessary linear flow through the open ones can be considerably reduced. Shielding against penetrating radiations must be adequate, and it has to be remembered that the use of massive shielding may require special construction to take the extra weight.

Hoods for work with radioactive isotopes at the 'low'[24] and 'semi-hot'[25] levels have been described in the literature, and further data are contained in some of the general references already given. Fig. 4 shows a typical arrangement of a bank of shielded fume cupboards with ancillary monitoring and handling apparatus for working with γ-emitters at the 100 mc. level.

Conclusions

Perhaps the most important fact which emerges is that the application of radioactive materials does not necessarily involve the user in the construction of unusually elaborate or expensive laboratory accommodation. The provision of special apparatus such as counting and monitoring equipment has, of course, to be faced, but the cost of this should be compared with that of any other modern physical apparatus.

The main requirement is the adoption of the correct techniques to prevent the spread of contamination about the open laboratory. If this is properly controlled, the commonly used $\beta\gamma$ isotopes, in the quantities which are frequently sufficient for academic and industrial research or process control investigations, may be handled without extensive modification of a modern, conventional chemistry laboratory. At the microcurie level, little is required beyond good fume-cupboard accommodation. With millicurie amounts the exposed laboratory surfaces should be capable of easy cleaning and decontamination in the event of accidents. It is only above the millicurie level that the need arises for special arrangements to provide adequate shielding and storage of radioactive sources, and for exceptional precautions in their handling and disposal.

Acknowledgments

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Book Reviews

Pipe resistance

In designing process plant it is, of course, important to calculate the most economical size of pipe to use. This requires accurate information on the subject of resistance. Without this, piping of too small a bore may be specified which may prove expensive to alter at a later date. More often, however, the pipe will be too large and add unnecessarily to the cost of the installation. The object of this book* is to provide a simple and accurate means of estimating pipe resistance for the flow of oils, spirits and other non-aqueous liquids. The author has devised a series of pipe-resistance diagrams which cover a wide range of conditions. It is comparatively simple to select the most appropriate one and obtain without calculation the answer to any particular problem with a fair degree of accuracy. Preceding the series of diagrams is a short section on practical considerations, the use of diagrams and the data required. This book supplies data which should help all chemical engineers.

**Pipe Resistance*, by T. E. Beacham. Spon, 1951. Pp. 61, 18s.

Chemical mathematics

The student beginning his studies in chemistry must rapidly learn an almost entirely new language, complete with names, symbols and rules of grammar. He must absorb chemical theory, expressed in a mathematical language which provides a basis for unifying a great deal of the subject matter. This book,* written by the Professor of Chemistry at the University of Southern California, has been compiled to help the beginner adjust himself to this new language of chemistry. It will help the young student overcome the difficulty of applying mathematical reasoning to physical problems, because it offers a consistent and integrated approach to the use of mathematics in chemistry.

The book contains 17 chapters, starting very simply with the basic standards for measurement followed by a description of methods of measuring quantities and the interpretation of chemical formulae. The other chapters discuss chemical reactions, energy and chemical changes, the properties of gases, valency, measurement and physical properties of solutions, chemical equilibrium, ionic solutions, hydrolysis, oxidation and reduction, Redox reactions, and rates of chemical reactions. There are three appendices giving, respectively, some mathematical definitions and operations, a table of common units and the answers to problems provided throughout the text to test the reader's progress.

**Chemical Calculations*, by S. W. Benson. Chapman & Hall, 1952. Pp. 217, including appendix and index. 24s. net.

Fluidised-Solids Conveyors

THE efficient handling of powder or granular materials in bulk can prove a very difficult task. The material may have a marked tendency to cake; it may be hygroscopic or become sticky when damp; it may give rise to serious dust hazards; and it may be abrasive and cause excessive wear on any machinery with which it comes in contact. These factors and many others must be considered when making the selection of a conveyor.

The air slide, or fluidised-solids conveyor, provides a method of handling materials which is virtually unknown outside the cement industry and which will, perhaps, prove the solution to many conveying problems. Great interest was aroused by the model exhibited by the Royal Doulton Potteries at the Castle Bromwich section of the 1952 B.I.F., yet, despite the fact that large quantities of porous ceramic tiles have been supplied by the company to the cement industry for the construction of these conveyors, knowledge of materials which can be handled, of capacities, power consumption and other technical data is so limited that for the present only experimental installations can be considered for other industries. Accordingly, the company intends to undertake a long programme of investigation and reports will be published periodically.

The air slide consists essentially of a trough which is divided into two compartments by a bed of porous ceramic tiles. The upper compartment is the conveyor along which the material travels and may be left open or enclosed as circumstances demand, whereas the lower compartment is completely enclosed except where air inlet ports are provided. Air entering the lower compartment can only escape by way of the porous tiles and must also pass through any powder in the trough above the porous tiles.

Any powder or granular material is characterised by what is known as the 'angle of repose,' which is the steepest angle at which it will rest on itself without sliding. Similarly, the material will not slide down a ramp or chute if the angle of slope is too small. These critical angles, frequently of the order of 30°, are determined by the friction between the particles or between the material and the surface upon which it rests. In the air slide the particles are lifted off the porous tiles by a cushion of air and are likewise maintained in a state of very loose packing by a film of air between adjacent particles, with the result that friction is reduced and the material will flow down a very shallow slope.

Raw cement is transported over considerable distances down air slides which are, in general, inclined at angles of less than 5° to the horizontal. Sand which will not slide down a polished copper ramp inclined at 30° to the horizontal, will move readily along an air slide at an inclination of only 1°.

The necessary air stream through the tiles is generally achieved by blowing air into the lower compartment; alternatively, suction may be applied to the compartment above the tiles. There are no moving parts requiring maintenance other than the blower, which can readily be completely enclosed or otherwise protected from wear. Air is filtered (using porous ceramic filters) before it enters the bottom compartment to ensure that the diffuser tiles do not also act as filters and in certain circumstances the air leaving the system may be filtered.

Figures for a typical test run on a miniature air slide were as follows:

Slide width	2¼ in.
„ length	4 ft.
„ slope	4°
Diffuser tiles ..	Grade G5
Filter tubes ..	Grade G4
Air supply	15 cu.ft./min. approx. from a 24-V blower
Pressure beneath tiles	0.8 in. w.g.
Material on test ..	Sand (air dry)
Approx. grading of sand	60% − 80 + 150 mesh 40% − 150 + 200 „
Feed rate	15 lb./min. approx. (8 cwt./hr.)
Depth of sand on tiles	¾ in. approx.
Velocity of sand along the conveyor ..	20 ft./min. approx.

In this test, the feed rate was the maximum attainable from the hopper feeding the conveyor. Improved equipment now being installed will, it is hoped, enable accurate data for many types of material and under various sets of conditions to be obtained.

Air slides will operate equally well with either a continuous or an intermittent feed, an important consideration. In addition, provided the feed is correctly designed, the conveyor does not become overloaded when take-off from the discharge end is stopped, for movement along the whole length will cease automatically. This characteristic is of great value when the conveyor is being used for the filling of sacks or packages.

The company's experience of the conveyor has so far been confined to the applications outlined above, and there remain many possible applications to be studied, such as the use of hot air to dry or even to heat material and the use of cold air to bring about cooling from elevated temperatures. Already enquiries relating to many different types of powder or granular materials have been received which have helped considerably in planning the course of investigations.

Distillation

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Chemical Engineering Invention

MONTHLY SUMMARY OF PATENT CLAIMS

Sulphur removal from industrial gases

Sulphur compounds are removed from industrial gases by scrubbing with an amine associated with an absorbent oil to form an amine-sulphur complex, separating the gas from the amine and amine-sulphur complex and extracting the complex with water which is immiscible with the scrubbing medium. Coke oven gas is scrubbed in a tower 1 with a wash oil containing 3 to 5 g./litre of piperidine to absorb sulphur compounds, especially carbon disulphide, carbonyl sulphide, carbon hydrogen sulphide, mercaptans, etc. Piperidine vapours carried off by the gas react in a water scrubber 4 with carbon dioxide present in the gas, or hydrochloric or sulphuric acid, ammonium sulphate, etc., solutions may replace the water.

The scrubbing medium passes through a delay tank 8 to facilitate reaction between piperidine and sulphur compounds dissolved in the wash oil, the free piperidine content in the tank being restored by connection with the condenser 11 of a still 10 in which piperidine is vaporised off from salts formed in scrubber 4 and a still 33 in which with the aid of a stream of coke oven gas organic sulphur compounds are vaporised off from liquids mixed with an acidic reactant such as hydrochloric or sulphuric acid or ammonium sulphate in a chamber 30; or the sulphur compounds may be separated by absorption in light oil. The scrubbing medium from tank 8 flows into a contactor 13 containing water and consisting of a vertical pipe, *e.g.* 48 ft. high and 2 in. diameter with a top section 20 of 8 in. pipe. Tower fillings 24 above the 30 ft. level and 26 below the inlet destroy unstable oil-water emulsion, providing a quiescent zone 25 of revivified oil for re-use in scrubber 1 and a zone 27 of water solution free of oil, to be acidified in chamber 30.

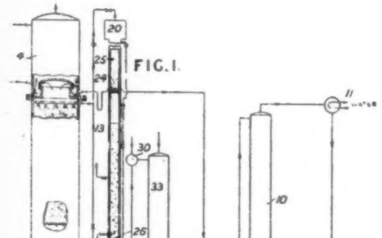


FIG. I

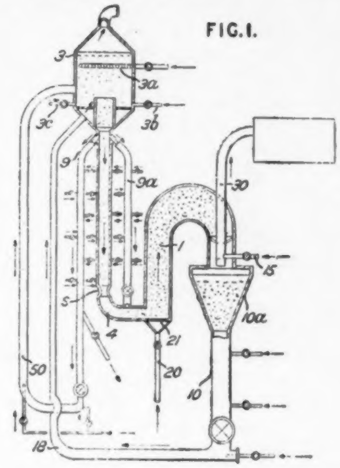
The desulphurised piperidine sulphate solution from still 33, with piperidine carbonate from scrubber 4 is treated with sodium or calcium hydroxide in a sump 38 feeding still 10 in which free piperidine is vaporised. In a modification, water solution from contactor 13 is mixed with half its volume of a creosote oil, benzene or other cyclic hydrocarbon, and treated for 15 min. with carbon dioxide under 60 atmospheres pressure, the mixture then separating out to water solution which is passed to sump 38 and oil solution of sulphur compounds which is treated in desulphurising still 33. The scrubbing medium may comprise primary amine such as mono-ethanolamine and iso-octylamine or secondary amines such as morpholine and its homologues, or a hydrogenated tar base fraction obtained from a fraction originally including pyridine, quinoline, isoquinoline and their homologues. As solvent for the amine, water, aliphatic alcohols, ketones, mineral oils, coal tar oils, and petroleum wash oils may be used.

The specification as open to inspection under Sect. 91, comprises also the removal of inorganic sulphur, *e.g.* hydrogen sulphide or organic sulphur, from other fluids such as hydrocarbon oils. Also, the revivification medium in contactor 13 may comprise inorganic salt solutions, as of calcium chloride, sodium thiocyanate and alkali-hydroxides, and organic liquids such as tricresyl phosphate and glycerol. This subject-matter does not appear in the specification as accepted.—617,780, *Koppers Co., Inc.*

Catalytic cracker control apparatus

An apparatus for controlling chemical reactions of short duration comprises in combination an elevated catalyst regeneration vessel 3, a reaction vessel 1 positioned below the regeneration vessel, a stand-pipe 4 connecting the regeneration vessel with the reaction vessel so as to conduct a natural flow of the fluidised catalyst from the regeneration vessel to the bottom inlet of the reaction vessel, means such as a pipe 20 and a distributing screen 21 for introducing a gasiform reactant into the bottom inlet of the reaction vessel so as to pick up and carry along in suspension through the reactor to its upper outlet the fluidised catalyst flowing from the stand-pipe, the outlet of the reactor being substantially below the level of fluidised catalyst in the regeneration vessel, a catalyst separating device 10, 10*a* at the outlet of the reaction vessel for directly receiving the catalyst suspension discharged from the reaction vessel and for separating centrifugally and by gravity the catalyst from the gaseous reaction products,

FIG. I.



and means such as a pipe 15 for injecting a quenching medium into the gaseous reaction products as or immediately after they are separated from the catalyst discharged into the separating device. A constriction *S* of which more than one may be provided, imposes a pressure differential between the reaction zone and the regenerator stand-pipe. A pipe 18 returns the fluidised catalyst from the separating device to the regeneration vessel; and a valved draw-off pipe 9, a valved auxiliary stand-pipe 9*a* and a catalyst recycle line 50 are provided to control adjustably the level of the catalyst in the regenerator, the catalyst temperature and the amount of catalyst passing to the reaction zone. The regenerator is provided with cooling tubes 3*a* an auxiliary fuel injection line 3*b* and a gas inlet 3*c*. A line 30 is provided for the removal of the reaction product. Suitable quenching materials include condensable liquids of high latent heat or cold, solids such as fine sand, brick dust, carborundum powder, silica gel, powdered metals or alloys, or catalyst. The use of the above apparatus for the dehydrogenation of butene is described employing a temperature of 1,050° to 1,250°F., a contact time of 0.5 to 5 secs., and a catalyst of molybdenum oxide, chromium oxide, molybdenum sulphide, chromium sulphide, nickel sulphide, tungsten sulphide or other known dehydrogenation catalyst having a size of 100 to 500 mesh. The apparatus is also applicable to the cracking of hydrocarbon gases or vapours at 1,800° to 2,600°F. to produce acetylene, ethylene and other low-molecular weight olefins and hydrogen.—619,761, *C. Arnold* (*Standard Oil Development Co.*).

Chemical Engineering in the U.S.A.

(*Concluded from page* 488)

Technical advances

One chapter describes the *Houdry* and *Thermophore* catalytic processes and the fluidised catalyst systems as used in the petroleum industry. These have been dealt with in the technical journals and little new information is given, except the startling fact that no less than 1,000 tons of catalyst a day are used by American industry.

In discussing the methods for separating homogeneous mixtures the hypersorption process is described and its applications given. The section on distillation columns contains little new, but suggests that the Americans are re-examining perforated plate columns and that packed columns are more favourably considered now that their limitations are better known.

In the laboratory field, reference is made to the Dixon gauze and Watson double gauze packings, both of British origin. The use of extractive distillation is stressed, but no new applications are given. Here, however, Europe has lagged behind in application after almost developing both extractive and azeotropic distillation. The report rightly points out that the improved laboratory packings have not yet been equalled on the large scale.

In the discussion on heat transfer, the increasing use of radiant heat transfer from burning oils is worth noting; a radiation type boiler with cyclone burners was seen. There is a general preference for *Dowtherm* for heating in the range 180 to 360°C., whereas high-pressure water is often used in Europe. The use of a pebble heater is worth attention as a new development and the standardisation of heat exchangers is much to be encouraged.

Features of especial interest are the use of the Podbielniak rotating extractor and the development of the Bird-Young rotary filter, in which the revolving valve is replaced by a sliding shoe connecting the discharge section of the drum to compressed air and the rest to vacuum. The use of continuous settlers as opposed to normal filters and the standardisation of the agitator equipment are further advances which apparently have not yet reached Europe to any extent.

The main comment is that European makers should extend their services to customers with more liberal provision of design information and pilot plant facilities. The specialist American firms are also more concerned with new developments.

Materials of construction

This chapter describes the general trend in America, but brings out little new. The greater availability of stainless steel and the technique for welding so as to reduce carbide precipitation and enable the simpler forms of stainless steel to be used are of interest.

Teflon and *Kel-F* from Kellog's are regarded as the best packing materials for corrosion resistance, and both are used for coating steel. Aluminium is more extensively used for pressure vessels and for instrument tubing. Again, the layer method of making pressure vessels developed in Europe appears to be more widely used in America.

Transport and storage of chemicals

Tank cars are the most important method for handling liquids in bulk and the two smaller sizes of 8,000 and 10,000 gal. capacity are the commonest, though capacities to 20,000 gal. are used. Rubber linings, plastics, enamel and nickel cladding are all used for protecting the car and for nitric acid stainless steel cars are used. Liquefied gases and volatile liquids are taken in similar cars tested to 42 kg/cm.^{2} gauge. For solid products, rail hoppers of 45 and 64 tons are common. One of the most interesting features is the existence of a number of companies which lease out cars, thus making it unnecessary for firms to have excess cars in reserve for peak loads. They can also obtain return loads and give excellent maintenance. The problems and methods for transporting natural gas by pipeline and the use of hortonspheres are discussed. There is little doubt that Europe could profitably increase the transport of chemicals on American lines.

Conclusions

The report is essentially a plea for more chemical engineering of the American pattern. To what extent do we in Britain show signs of treading this path? Since 1945 we have made considerable progress and have a number of university courses that are equipped to give a training that is comparable with that in the U.S., although we are weak in providing laboratory facilities on anything like the American scale. Do these courses show the academic trend criticised in the report or are they leaning towards a judicious blending of theoretical principles with practical empiricism? Are we training men to give us a lead in 'application engineering'?

Again, the report suggests that there are a number of technical processes used in America that have been but slowly introduced to Europe. The chemical equipment companies are urged to be more liberal with design data. There can be little doubt that the advertisement literature freely offered by American firms has brought their equipment into world-wide use. The section on the large chemical engineering companies is the most important, as it puts on record for the first time the great part they play in chemical plant construction. It is a pity that more time and space were not devoted to the question of the activities of these companies in ordinary chemical plants. Are the American chemical companies getting their plants designed and built by these firms? This is not considered. Should Europe develop these big companies? A clearer opinion from OEEC would have been valuable, whereas all that is really said is that America has the last word in knowledge of refinery construction and that we must acquire it.

The report suggests that slavish copying of the American specialist technique would not by itself improve matters, since it is teamwork that builds big plants. We are not producing many specialists from our universities, for the number of those doing research in unit operations is small compared with America. We have, however, started in earnest to provide a stream of research papers from our universities so that the claim that America has provided all the texts will soon have to be modified.

If we are to build up chemical engineering to the same high place that it has in America, then it will be necessary to turn a far greater percentage of our best students away from the pleasant field of arts to the field of technology and applied science. The American is proud to be an engineer. Are we just as proud, or do too many look for administrative jobs?

Capital put into chemical engineering has paid a good dividend in America. Why shouldn't it here? So far we have been niggardly in spending money in this field.

Recent publications

Flaw detection. In recent years the economic necessity for increased production, together with mass production and the widespread application of welding processes, has resulted in a demand for methods of non-destructive flaw detection. In a new leaflet the Manchester Oil Refinery Ltd. describe their *Supramor* electromagnetic flaw detection ink for the application to metal for detection of fatigue, stress and heat treatment cracks, forging flaws, non-metallic inclusions and blow holes in iron and steel castings.

Ultrasonic soldering. The principles and methods of use of their ultrasonic soldering equipment are described in a recent publication from Mullard Ltd. This equipment, which consists of an ultrasonic soldering iron and an ultrasonic tinning bath, makes possible the effective tinning of aluminium and other light metals without the use of flux. Typical applications include the tinning of electronic chassis assemblies, the soldering of connections to aluminium foil condensers, and the filling of blow holes and other faults in light alloy castings.

Laboratory specialities. Full technical specifications of special instruments are given in the latest catalogue published by Griffin and Tatlock Ltd. The catalogue, number 16B-S, is well illustrated and contains an index.

Plant and Equipment

Low-temperature evaporator

Low-temperature evaporation and short time of contact with heat are two of the most important factors in the concentration of liquid foodstuffs, fine chemicals, antibiotics and other heat-sensitive materials. A new evaporator for the continuous concentration or distillation of liquids has now been evolved, which operates at low temperatures without the use of steam. Known as the *Coolcentrator*, it is made by the Kestner Evaporator and Engineering Co. Ltd., and it actually concentrates while the liquor is quite cool.

Ammonia gas is suggested as the heat transmission medium, although other gases such as methyl chloride or *Freon* may be employed.

The plant comprises essentially a climbing film calandria, separator and condenser, together with a compressor. Ammonia gas is heated by compression and delivered into the heating space of the calandria, where it condenses, giving up its heat to the liquor being concentrated. The condensed liquid ammonia is cooled by passing through an expansion valve, thence into the tubes of the condenser where the pressure is lower than in the calandria.

The water vapour removed from the liquor in the calandria passes to the outside of the condenser tubes, where it condenses on the cold tube surface. In so doing it evaporates the liquid ammonia in the condenser and the resulting ammonia gas passes on to the suction side of the compressor and is pumped back into the heating space of the calandria.

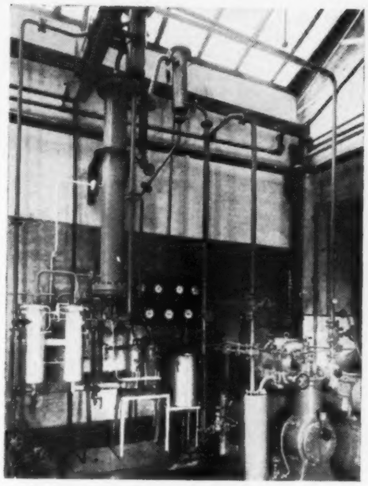
Thus the ammonia circulates continuously round a closed circuit, receiving heat in the compressor and losing heat in the calandria. In principle the ammonia circuit is similar to a refrigeration plant, except that in the *Coolcentrator* the functions of the usual refrigerator ' condenser ' and ' evaporator ' are reversed. The heat absorbed in the calandria is not always completely balanced by the heat released in the condenser, so that in practice suitable means are provided for effecting the desired balance by use of a ' balance ' cooler.

The operating temperature may be varied over quite a wide range to meet individual requirements. For instance, the concentration of liquor can be carried out at atmospheric temperature, when the temperature of ammonia gas in the evaporator would be about 40°C., with the liquor boiling at 15°C. and the condenser working at 15°C. The plant is, therefore, suited for the distillation of such solvents as acetone and amyl acetate.

The compressor operates simply as a heat pump, and may be driven by any convenient prime mover, such as an electric motor, diesel engine or gas turbine.

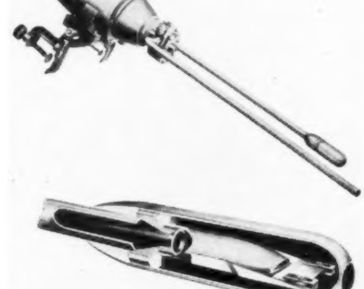
On the liquor side the plant, of course, operates under vacuum, this being maintained by any of the normal methods, *e.g.* a reciprocating or rotary vacuum pump, or a multi-stage ejector. The evaporating temperature of 15°C. mentioned in the foregoing corresponds to a vacuum of approximately 29$\frac{1}{2}$ in. (13 mm. absolute pressure), which is easily obtainable by means of standard equipment without involving special high-vacuum technique.

It is claimed that there is no difficulty in removing the concentrated liquor. Where height permits a barometric discharge, which obviates moving parts, is recommended. Alternatively, a liquor extraction pump, or in the case of a small plant, vacuum receivers, may be fitted.



The ' Coolcentrator '

For further information on new plant and equipment please complete the coupon on page 512



Ultrasonic emulsifier, which is portable and can be clamped on to mixing vessels. Below is a section through the emulsifying head.

Ultrasonic emulsifier

A new ultrasonic emulsifying machine known as the *Rapisonic* is based on the principle of the Pohlman Whistle.* The vibrations are brought about by a jet of liquid impinging on a blade which vibrates at its natural frequency. Both jet form and blade are enclosed by a resonant bell, which concentrates the local ultrasonic effect.

Emulsification takes place when cavities are swept out by the blade, which is oscillating at about 30 kc./s.—a frequency beyond the range of audition. On the collapse of these cavities instantaneous local pressures of the order of 30,000 p.s.i. are built up. This is the basis of the machine's efficiency. Although there is still some doubt as to what actually causes the dispersion, it is certain that the cavitation plays the main part and that other effects are secondary.

It is well known that in order to intermingle one normally insoluble fluid with another a high concentration of energy is needed.

Generally, the greater the amount of energy released on fluids the more intensive is the breaking down and consequently the smaller the particle size of the dispersion. With ultrasonics the great advantage is that a great concentration of energy is possible. Mechanical methods of producing ultrasonics are concerned with sound strengths in order of 1 to 2 watts/sq. cm., and when one considers that this is several million times stronger than the sound from the average radio speaker, some idea of the energy concentration can be formed.

The limit of audition in air is a wave of approximately 2 cm. in length. In liquids the figure is approximately 10 cm. Anything above this range is classed as ultrasonic and the wavelengths are correspondingly shorter. It is the short-wave feature of ultrasonics which enables them to be easily directed, whereas with sonic frequencies only a comparatively small degree of direction is possible.

The *Rapisonic* has an output of 420 gal./hr. and has the additional advantage of being fully portable; it can be clamped on the side of existing mixing vessels. All parts in contact with the liquids are of stainless steel and other parts are made in light-weight alloys, wherever possible, to keep the power/weight ratio down to a minimum.

The frequency at which the blade vibrates can be adjusted. The internal parts of the ultrasonic head can be dismantled by hand for cleaning.

The machine is made by Ultrasonics Ltd., and its price is said to be well below that of conventional emulsifiers or homogenisers.

* This device was fully described in the article, ' Emulsification with Acoustic Waves,' by P. Alexander, *Manufacturing Chemist*, January 1951.

World News

GREAT BRITAIN

S. American engineers to train in U.K.

The British Engineering Training Mission to Latin-America has recently completed a tour of Colombia, Venezuela, Cuba, Mexico, Peru, Chile, Argentine, Uruguay and Brazil under a scheme approved by the Board of Trade and the Federation of British Industries. The main purpose of the mission was, firstly, to investigate the technical training arrangements for young engineering graduates in these countries with a view to providing a number of them with scholarships for practical training in Britain and, secondly, to make known to all concerned the exceptional practical training facilities which Britain can offer.

The scholarships which will be offered to the Latin-American countries are an extension of the general F.B.I. Overseas Scholarship Scheme which was established two years ago, as part of a long-term export trade policy as well as to assist overseas countries in process of economic development.

Silicone rubber production

The silicone plant now being constructed by Albright & Wilson Ltd. is expected to come progressively into full production during 1953. Silicone rubber is the first silicone product to be made in Britain and certain grades are now being manufactured, although not without partial dependence upon imports from America.

All the silicone rubber is to be sold by a subsidiary, Midland Silicones Ltd., and it will be called *Silastomer*. This name will be given to both the imported Dow Corning *Silastic* and the material made in Britain.

Recovering silver from *x*-ray films

The means by which something like 500,000 oz. of silver, worth over £150,000, can be recovered from used *x*-ray film each year, have been indicated to hospital authorities in England and Wales by the Ministry of Health. Silver recovered will be returned to the *x*-ray film manufacturers, so helping to overcome the shortage of this metal—a dollar import.

Unlike photographic film, *x*-ray film is heavily coated on both sides of the base and is no less than six times richer in silver. When *x*-ray films are processed, 80% of the silver is left in the hypo fixing bath, the other 20% remaining in the finished film in the form of the black 'image.' The silver can be recovered from fixing baths either by electrolysis or by chemical methods. Used film is sold to refiners on the understanding that the silver recovered goes to the *x*-ray film manufacturers.

Mr. W. Leonard Hill congratulates Mr. J. A. Reavell at the birthday dinner described below. In the centre is Mr. W. S. Knight.

Doyen of British chemical engineering

In spite of his age, J. Arthur Reavell, chairman of the Kestner Evaporator and Engineering Co. Ltd., spoke and acted like any other member of the distinguished party which gathered to toast him and wish him luck on the occasion of his eightieth birthday at the Savoy Hotel, London, recently.

Sir Harold Hartley, past-president of the Institution of Chemical Engineers, proposed the guest's health. He referred to their early days and to his work with Mr. Reavell and the Kestner company. He recalled that Mr. Reavell was the founder of the Chemical Engineering Group of the S.C.I. and that his name is number two on the list of original members of the Institution of Chemical Engineers. Also, that as a result of his visit to South Africa the first branch of the Institution in the Union was founded.

William S. Knight, our friend of some forty years standing, secretary of the Company, spoke easily and well, and welcomed, in the name of the company, Kestner men from South Africa, France, South America and elsewhere. He reminded us that even the book-keeper finds that the chemist, or at any rate, chemicals, have their direct uses. He spoke for the whole of the staff of the company in his congratulations to "their beloved chairman."

Mr. John Lane, who looks like and spoke like the traditional engineer, presented a loving cup to Mr. Reavell to mark the occasion.

Mr. Dunbar Ferns, from Scotland, spoke in what can best be described as warm, generous terms.

Mr. Walter Addison, the representative from South Africa, mentioned the lasting impression Mr. Reavell had left behind him there.

Dr. Colgate recalled the S.C.I. meeting in Birmingham, of more than two decades ago, by presenting his friend Arthur with a caricature drawn at that time.

Further reminiscences of the early years and of J. A. Reavell's great part in improving the status of chemical engineering and in obtaining recognition for the chemical engineer, came from Dr. Leslie Lampitt and M. Myon of Lille.

Telegrams were read from various parts of the world by Mr. Brian Reavell.

The guest of honour then gave his reply, and from the first words proved that his mental alertness was in no way overshadowed by his physical agility. Without notes, he ranged over the last fifty years in chemical engineering. He recalled great names of the past: Edgar Duché, who first introduced him to Paul Kestner; the erratic Kestner himself and amusing incidents at the Mansion House and elsewhere; of experiments in the kitchen at sugar making; of his early work for Foster Wheeler; of the attempts of the fabulous Charlie Schwab to bring about an international engineering association similar to that which he had previously effected with American steel and railways. He gave interesting outlines of the first spray-drying installation, an American idea, incidentally, built first in Cherbourg; of the early power stations; of the first cooling tower, built on American designs in association with Charles Markham; and of the early lessons learned by the Americans in attempting to introduce systems appropriate to their own country at that time but singularly and fatally inappropriate to conditions in England.

The dinner was good, the planning was good, and the speeches were good. Mr. Reavell finished on time to give those present an opportunity of exchanging reminiscences with him and with their other friends and associates.

In the presence of the agile and youthful guest of honour it seemed an obvious remark, but most people made it—"We will keep the same day vacant ten years hence."

Ash and clinker in industry

A conference entitled 'Ash and Clinker in Industry' and organised by the Institute of Fuel is to be held in London on October 28-29. The programme covers a wide field, dealing with industrial fuel-burning plants of many types and the effect upon their performance of ash and clinker from various fuels, subject only to exclusion of treatment of liquid fuels. Special attention is devoted to steam-raising plants, which consume a large proportion of the coal used by industry.

A complete set of preprints will be supplied in advance to each conference member so that questions and comments can be prepared beforehand.

Chemical engineering and chemistry at British Association meeting

Chemical engineering in industry was discussed at a session of the Engineering Section at the British Association for the Advancement of Science meeting held in Belfast from September 3 to 10. In one paper Prof. D. M. Newitt, Imperial College of Science and Technology, discussed the place of the chemical engineer in higher technological and technical education in the light of the functions of a chemical engineer in industry. Dr. E. H. T. Hoblyn, director of the British Chemical Plant Manufacturers' Association, stressed the national need for chemical engineers and described their training and their relation to the chemist and other types of engineer. Sir Harold Hartley, immediate past-president of the Institution of Chemical Engineers, then opened the discussion on chemical engineering in industry. It is hoped to give a more detailed account of this session in a later issue of CHEMICAL & PROCESS ENGINEERING.

In the Chemistry Section meetings, which were spread over three days, including afternoon factory visits, 12 papers were given. Prof. W. Wardlaw, Birkbeck College, London, opened the proceedings as sectional president with a paper on 'The Advancing Front of Chemistry.' Progress in organic chemistry was reviewed by Dr. D. H. R. Barton, Birkbeck College, and in organic and physical chemistry by Prof. A. R. Ubbelohde, Queen's University, Belfast. There was a symposium on new and old fibres, dealing with both natural and synthetic products. The papers included one by Dr. Rowland Hill, Imperial Chemical Industries Ltd., *Terylene* Council, on the principles underlying fibre formation in synthetic polymers and on their properties and applications. There was also a session on food processing, with a paper on the chemistry of breadmaking and another on fish processing. The processing of fats, including the manufacture of margarine and cooking fats, was described by Mr. P. N. Williams, Unilever Ltd.

In the Physiology Section one session was given to antibiotics in animal nutrition. Dr. F. J. Cuthbertson, Glaxo Laboratories Ltd., dealt with antibiotics and the animal protein factor and Dr. M. E. Coates, National Institute for Research in Dairying, described the mode of action of antibiotics.

A historical science paper was given by Mr. E. V. Lane on 'Some Aspects of the Early Development of the British Rubber Industry.' The work of such men as Hancock, Macintosh, Wickham and Dunlop in establishing the industry in the 19th century was described.

The subject at one of the three evening discourses was 'Oil in Peace and War,' by Mr. A. C. Hartley, the past-president of the Institution of Mechanical Engineers.

Development of potash deposits

The Secretary for Overseas Trade, Mr. Mackeson, was recently asked in Parliament what progress was being made in the development of the potash deposits in Yorkshire. He replied that a great deal of exploration and proving work had been undertaken, but the economic exploitation of these deposits set many problems. All the relevant knowledge and experience were being collected and examined as quickly as possible.

New school for apprentice engineers

With a record of apprenticeship training which goes back for more than a century, Baker Perkins Ltd., manufacturers of bakery, laundry and chemical process machinery, are developing their apprenticeship schemes by building a complete trades school which will supersede three existing workshops. This new development will include, for the exclusive use of the company's apprentices and trainees, a machine shop, tool room, fitting and erection shop, a fabrication shop with welding bays and all the attendant engineering services. The apprentices and trainees will also be provided with a lecture hall, gymnasium and changing accommodation with showers and heated lockers.

The new school and the various apprenticeship schemes are described by the company in an attractively produced booklet entitled 'Opportunities in Modern Engineering,' compiled for school and college students and their parents wishing to know of the opportunities in the engineering industry.

More butane for town gas

The use of butane as town gas was started at Whitland, North Wales, in January of this year consequent upon the establishment of a considerable oil refining industry in Britain (see this journal, March 1952, p. 120). This experiment has proved so successful that the Wales Gas Board is planning similar conversions at Fishguard and later at several other undertakings. Other gas boards in Britain are said to be placing orders for butane gas-making plant.

Although the cost of producing butane gas on this experimental scale is higher than would be the case under straightforward conditions, it is still about the same as for coal gas. It is expected that the present adverse factors will later be largely eliminated. For instance, transport costs will be reduced by grouping stations fitted with static tanks and capable of being serviced at one delivery of neat butane from the Llandarcy refinery, 40 miles away. Operating costs will also be cut when the experiments are concluded and the process made automatic.

New coke-oven plants

The Durham Divisional Coal Board has begun preliminary work on a £2,000,000 coke-oven plant at Burnmoor which is expected to be completed within three years. The works will include 52 coke ovens and ancillary plant for extracting by-products, and will have an output of 5,000 tons of coke a week.

Public trading in lead to end

The Government has decided that private trading in lead can be restored as soon as the necessary arrangements can be made by the Ministry of Materials and the trade. Discussions with the trade will take place at once, and it is hoped that it will be possible to give effect to the decision on October 1. A further announcement about the date will be made as soon as possible. From the date of reversion the private import of virgin lead will be permitted and the London Metal Exchange will reopen for transactions in lead. The Ministry of Materials will cease to trade in lead, except to the extent necessary to wind up its trading operations. This was announced in Parliament on July 28.

Materials for paper making

Asked in Parliament the total value in 1951 of esparto grass and pulp-wood imported for paper-making and whether he would encourage the industry to use a greater volume of home-grown straw for this purpose, Mr. Mackeson, the Secretary for Overseas Trade, replied that the c.i.f. values were £15,062,186 and £2,638,616, respectively. The Government would certainly give every encouragement to paper-makers who wished to use home-produced materials, including straw, but the latter required special plant for economic production.

Natural gas in Yorkshire

Application for permission to sink an exploratory borehole for natural gas and, subsequently, if gas is found in sufficient quantities, to work the borehole as a production well, has been made to the Whitby Rural District Council by Imperial Chemical Industries Ltd. Although it is known that there is natural gas in this part of Yorkshire, there is no certainty that quantities are sufficient for exploitation. Also, some practical means must be devised of getting the gas to the surface and storing it. The solution of these problems would be an important contribution to the conservation of coal in this country, as the calorific value of methane is nearly 40% greater than that of coal gas.

New I.C.I. deputy chairman

Mr. Stanley Paul Chambers has been appointed a deputy chairman of Imperial Chemical Industries Ltd. Mr. Chambers, who is 48, has been a director of I.C.I. since 1947. There are two other deputy chairmen, Mr. A. J. Quig and Dr. A. Fleck. From 1937 to 1940 Mr. Chambers was Income Tax Adviser to the Government of India and in 1942 he became a Commissioner of Inland Revenue —a position he held until joining I.C.I. in 1947. From 1945 to 1947 he was chief of the Finance Division, Control Commission for Germany, British Element.

New chemical plants

New plants which are either being built or have recently been completed by the Laporte Chemical Group were described by the chairman, Mr. L. P. O'Brien, in his statement at the annual general meeting.

A subsidiary, Laporte Acids Ltd., is building a new sulphuric acid plant at Hunt Works. Designed to burn pyrites, its rated capacity is 100 tons/day of 100% acid. A significant part of the output of this new plant has been sold for some years ahead. New laboratories have been built and equipped at Hunslet. The company's new hydrogen peroxide plant at Baronet Works, Warrington, has been operating for about two years and the first extensions to its original units are practically completed. The biggest job in hand is the building by the Laporte subsidiary, National Titanium Pigments Ltd., of a new titanium oxide plant with its attendant sulphuric acid plant at Battery Works, Stallingborough, north Lincolnshire. Both plants are likely to be completed by March 1953.

During the year, five subsidiary companies were wound up in order to simplify the structure of the group and to economise. They were: Associated Phosphate Manufacturers Ltd., Wm. Burton & Sons (Bethnal Green) Ltd., Genoxide Ltd., Laporte Minerals Ltd. (formerly Malehurst Barytes Co. Ltd.) and Hunt Brothers (Castleford) Ltd. This last firm was absorbed by John Nicholson & Sons Ltd., which has changed its name to Laporte Acids Ltd.

Sales figures for the year established new records by weight and by value. There was, however, a noticeable slackening in demand in the January-March quarter of 1952, which has continued to date. In spite of this, the main plants ran at capacity.

New B.S.I. chairman

The British Standards Institution has elected Mr. John Ryan as its chairman to succeed Sir Roger Duncalfe, who had completed his three years' term of office. Viscount Waverley was re-elected president of the Institution for the third year. Sir Roger Duncalfe was elected vice-president.

Mr. Ryan is vice-chairman of the Metal Box Co. Ltd., and he has for many years played a leading part in the standardisation policies implemented through B.S.I. by the packaging industry. He was appointed chairman of the Packaging Standards Committee on its formation in 1941, and was intimately concerned with the development of the wartime Packaging Code. This not only resulted in dramatic economies in packaging materials and labour during the war, but through the progressive accumulation of technical data has since made available to British industries the most economical and efficient packing techniques, particularly in the export field.

Behenic acid now made

Since they came into production in 1950, Hess Products Ltd. have made a series of highly pure fatty acids on a commercial scale in their fractionating plant at Littleborough, Lancs., as well as offering a wide range of normal grades of stearine and fatty acids.

They now announce a new addition to their range with highly pure behenic acid. This is a saturated fatty acid of C.22 chain length and has the following approximate tests and composition:

Acid value	160-165
Saponification value	160-165
Iodine value	3 max.
Titre	74-76°C.
Melting point (complete fusion, capillary tube)	76-78°C.
Unsaponifiable..	3% max.
90% behenic	
8% stearic	
2% unsaponifiable	

It will be of interest to any company making waxes, chemical derivatives, metallic soaps, textile compounds, lubricants and any other products where a high melting point or long carbon chain length are necessary.

Institute of Materials Handling

Interest in the recently formed Institute of Materials Handling is such that already 360 applications for membership have been received, coming from as far afield as Argentina, Ceylon and S. Africa.

Mr. Alfred Roebuck, leader of the Anglo-American Productivity Team on Mechanical Handling, has accepted the invitation to become the first honorary member of the Institute. The chairman of the Council is Mr. H. P. Mott, Vauxhall Motors Ltd., deputy chairman, Mr. J. Bright, Joseph Lucas Ltd., and the treasurer, Mr. A. F. Much, Imperial Chemical Industries Ltd.

At the end of this month the subject 'Materials Handling—An Industrial Revolution,' will be discussed at meetings in London, Birmingham and Manchester. An inaugural general meeting and dinner will be held in October. Three lectures will be given in November on subjects of wide interest to all concerned with materials handling.

New Institute of Welding officers

Mr. A. Robert Jenkins, deputy managing director of Robert Jenkins & Co. Ltd., of Rotherham, was installed as president of the Institute of Welding for 1952-53 at the annual general meeting of the Institute on July 22.

Mr. Jenkins, who was educated as a mechanical engineer at Sheffield University and as a pupil apprentice with W. H. Allen & Sons Ltd., of Bedford, entered the family business at Rotherham in 1931 as plant maintenance engineer. Shortly afterwards he took charge of the works progress department, became works manager and a director of the company in 1934 and, in 1946, as works director, became responsible for the whole of the production and technical side of a works now producing about 1,000 tons/month of fabricated products.

Mr. Jenkins has travelled widely, visiting factories in Sweden, Germany and the U.S.A., and was a member of the Specialist Productivity Team on Welding, which visited the U.S.A. in 1950. He serves on the Council of the British Welding Research Association, the Rotherham and District Employment Committee and the Management Committee of the Sheffield Engineering Employers' Association, and has been president of the Rotherham Chamber of Commerce since 1950. He is a founder-member of the Sheffield branch of the Institute of Welding and president of the branch.

The new vice-president of the Institute is Mr. H. B. Fergusson, who for 15 years has been a director of G. A. Harvey & Co. (London) Ltd. Mr. Fergusson was educated as a mining engineer in Freiberg, Germany, and later articled to his father, a member of the Institution of Civil Engineers. He has had a distinguished career in railway construction and other engineering projects in Canada, Spain, South America and Russia, where during the 1914-18 war he was in charge of 750 Canadian railway men building the Murmansk railway.

ITALY

Sulphur output up

The Italian Sulphur Board (Ente Italiano Zolfi) estimate that Italy's sulphur output this year should be in the neighbourhood of 1,750,000 tons of ore with a yield of about 215,000 tons of fused sulphur. This yield would be equal to that for 1950. In 1951 the output was only 1,612,428 tons with a yield of fused sulphur of 200,478 tons, as the result of strikes and the exhaustion of some mines.

Forecasts for output of fused sulphur in future years are very optimistic. By 1954 output should reach the pre-war level of 400,000 tons.

This year will show the first results of the sulphur industry's research and development programmes. In addition, the stability of prices at rather high levels and the strong demand from European countries has induced producers to make new efforts to increase mining outputs. Research work, for which 950,000,000 lire was advanced recently, will be terminated within the three-year period 1952-54.

DENMARK

New office for British firm

A continental office has been opened by Sunvic Controls Ltd., London, manufacturers of temperature control and measuring equipment, to deal with their extending European interests. It is at Skindergade 38, Copenhagen K, Denmark.

HOLLAND

Largest European oil refinery

With an increase of more than 50% of its present crude oil processing capacity of 5,750,000 tons p.a., the Pernis (Rotterdam) refinery of the Royal Dutch-Shell Group will have a throughput of 9,000,000 tons p.a. by the beginning of 1954. It will thus become by far the largest refinery in Europe, including the U.K.

The additional capacity is to come from a new 3,250,000 tons p.a. distillation unit on which preliminary construction work has started. The present crude oil distillation capacity of the refinery is 5,000,000 tons p.a.; in addition, there is a yearly intake of 750,000 tons of crude oil from the Schoonebeek (Netherlands) oilfield.

This new project, estimated to cost £2,000,000, will mark a further phase of the post-war rehabilitation and new construction programme of the Pernis refinery which has already cost over £20,000,000. War damage repairs and replacements brought its capacity during 1946 back to the pre-war level of 1,000,000 tons p.a. and subsequent new plant construction has raised the figure to its present level.

HUNGARY

First penicillin factory ready soon

The first factory in Hungary to specialise in the manufacture of antibiotics has been built in the provincial centre of Debrecen, and will start penicillin production this year.

The new factory, named the Duclos Pharmaceutical Works, will produce enough penicillin to supply all Hungary's needs and to have a surplus for export. According to chief engineer Lóránt Sárdy, it will be one of the most highly mechanised plants in the country, with 13.5 h.p. available per worker.

The first Hungarian experiments in penicillin production started three years ago in the Chinoin factory in Budapest, under Dr. Zoltán Földi. Production has now reached the pilot-plant stage. The Duclos Works is based on the test plant successfully set up by the Chinoin factory.

SPAIN

Oil refining facilities enlarged

At the annual general company meeting of the Escombreras Oil Refinery the following figures were issued in respect of 1951. From 350,000 tons of Arabian crude oil the refinery produced: 73,000 tons of petrol, 86,000 tons of gas-oil, 143,000 tons of fuel oil and 17,000 tons of kerosene. New equipment is now being installed with a view to quadrupling present capacity, an eventual output of 1,500,000 tons of refined products a year being the target. The company also plan to set up a special plant for the production of lubricants.

General Franco has inaugurated some of the installations belonging to the State-sponsored Empresa Nacional Calvo Sotelo at Puertollano. This project is designed to produce petrol, kerosene, gas-oil and lubricants from the 1,200,000 tons of bituminous shale which will be processed annually. It is not known how far underground operations have progressed, but it is believed that it will be some time before the plant comes into full operation. This concern has been assigned $650,000 for power plant and $1,700,000 for electrical and mining equipment under the $62,500,000 loan administered through the Export-Import Bank. A recent decree law also authorised additional credits amounting to 3,735,000,000 pesetas for the production of liquid fuels under State auspices. Of this sum, 1,553,000,000 pesetas are to be earmarked for the Puertollano project.

GERMANY

Two more chemical firms freed from Allied control

Two West German chemical firms, the Titangesellschaft, Leverkusen, and the Chemiewerk Homburg, Frankfurt, which belonged to the former I.G. Farben chemical combine, have now been released from Allied control.

The Titangesellschaft, which manufactures dye products, will now be able to operate as a limited liability company under German law. The holdings of the former Farben combine in the company have been acquired by the United States National Lead Co. Allied and German authorities have agreed that the Chemiewerk Homburg shall be acquired by Degussa, of Frankfurt.

FRANCE

More natural gas

Natural-gas wells in the Saint Marcet area of the Pyrenees foothills, operated by the state-owned gas authority, produced a total of 10,000,000,000 cu. ft. of natural gas in 1951, compared with 8,600,000,000 cu. ft. in 1950.

At the end of 1951 a high-pressure deep gas horizon was encountered in a well at Lacq, near Pau (Basses Pyrenees), but the well blew out of control and had to be cemented and abandoned in February 1952. However, the well produced about 7,000,000 cu.ft./day for two months before it was plugged, along with a spray of light oil. Two other 11,700-ft. wells are planned for the area in 1952.

SOUTH AFRICA

Uranium from gold mining residues

Production of uranium from gold-bearing ores is expected to start at the end of September at the West Rand Consolidated mine. A secret process is to be employed by which uranium oxide is extracted from gold tailings, a mining residue. The U.K. and U.S.A. have financed the project and the Union is under agreement to sell the uranium to these countries (see this journal, February 1952, p. 96).

The West Rand plant is the first of several to be completed at various places in the extensive Union gold mining district.

TRINIDAD

New catalytic cracker

The installation of the new catalytic cracking plant by Trinidad Leaseholds Ltd. at Pointe-a-Pierre at a cost of approximately £4,000,000 is now nearing completion and is expected to be in operation soon. A large proportion of the equipment is of U.K. manufacture. This is the first occasion that such a percentage of an oil production plant for Trinidad has been obtained from Gt. Britain.

NORWAY

Graphite production to be doubled

The Skaland graphite works near Senja in north Norway are to increase output from 4,000 to 8,000 tons a year in the near future; 97% of the graphite is exported to the U.S.A., Gt. Britain, India, Italy and other countries.

Wood fibre spinning plant

Norway's largest wood processing company, A/S Borregaard, is building a plant for spinning staple fibre. Borregaard's output of staple fibre is 13,000 tons p.a., most of which is exported. The spinning plant now being built will have 23,000 spindles, later to be increased to 40,000, able to spin 3,000 tons of yarn p.a. The plant, to cost about £1,500,000, will begin production this autumn.

Mining industry to be developed

It has been proposed that some 41,000,000 kroner be allocated by the Storting for mining purposes, of which 30,000,000 kroner should be loaned to A/S Sydvaranger iron mines, 3,300,000 to pyrites refining, 1,700,000 to research into the Vaddas pyrite deposits, 2,000,000 to build a research plant for the Dunderland ores, 3,000,000 for research and experiments on Spitzbergen coal, 800,000 for Orsdalen wolfram and molybdenum mines and 200,000 for examination of the nickel-bearing ores at Raana. The support of the Mutual Security Agency is also sought in connection with the development of Norway's mining industry, and an indication of some $200,000 being granted by the M.S.A. has been given.

Cement output climbs

Christiania Portland Cementfabrikk, Norway's largest cement factory, celebrates its 60th anniversary this year. The company has spent 30,000,000 kroner on extensions since the war, thereby reaching an annual production capacity of approximately 355,000 tons, nearly half the total produced in the country. During 1951 some 720,000 tons were produced, compared with 332,000 and 390,000 tons for 1938 and 1939, respectively, but demand still exceeds supply and cement is therefore still rationed.

INDIA

Superphosphate factory at Sindri

A State-owned superphosphate plant is to be set up at Sindri, Bihar, close to the Sindri fertiliser plant. The factory is expected to cost about 5,000,000 rupees to erect and equip. It is scheduled to produce some 15,000 tons of superphosphates p.a. Plant and machinery have already been ordered.

Lignite mining scheme

An experimental open cast mining scheme to extract lignite in South Arcot district has been prepared by the Madras Government. The scheme is expected to cost 7,900,000 rupees. The Central Government will lend old machinery costing 1,500,000 rupees as their contribution to the working of the scheme.

Investigation has revealed the existence of about 2,000,000,000 tons of lignite in S. Arcot at a depth of 175 ft. The ore when processed would compare favourably with the grade 1 coal of Bengal.

Electrolytic copper to be produced

India, which at present produces only fire-refined copper, is to enter the electrolytic copper production field by means of a new process evolved for a 10,000,000-rupees silver refinery to be built in a Calcutta suburb. Work on the new plant is to begin almost immediately and is scheduled to be completed within 18 months.

The new process adopted has been evolved by an Indian expert in conjunction with Demag Electro - Metallurgie GmbH., of Karlsruhe, Germany, a partnership which has been entrusted with the supply and erection of the new refinery. Known as the Mitter-Demag process, it is being patented with the German firm as co-patentee.

The refinery will extract silver and copper from quaternary coins (coins made of an alloy comprising 50% silver, 40% copper, 5% each of nickel and zinc), which are now being replaced in India by nickel coinage. The amount of quaternary coinage minted totalled 600,000,000 oz.

It is also expected to handle silver refining for other Eastern countries.

CEYLON

Sugar factory planned

Ceylon's Industries Department is inviting tenders for building a sugar factory on the island with a unified system of cane transport and a distillery. Tenders for three sections are being invited—the sugar factory, the transport system and the distillery. Preference will be given to tenders incorporating the complete project.

EGYPT

Cellulose from rice straw

The Société Nationale du Papier, S.A.E., has increased its facilities for the manufacture of cellulose from rice straw with a view to doubling production capacity. This has involved the provision of extra water supplies for the mill.

Increased output of steel

Two 25-ton open-hearth furnaces (Fours Martin) and a new rolling mill with accessories for a yearly production of about 40,000 tons rolled steel have been bought by the Egyptian Copper Works, S.A.E. One furnace and the rolling mill were scheduled to start production this May, while the second furnace will be in operation this autumn.

ISRAEL

New salt company formed

London talks between representatives of the Government of Israel and Palestine Potash Ltd. have ended in an agreement which provides for the sale and transfer of all assets of Palestine Potash Ltd. situated outside the Hashemite Kingdom of Jordan to an Israeli corporation formed by the Government under the name of Dead Sea Works Ltd. The new corporation will be granted a concession by the Government of Israel to extract salt and minerals from all Dead Sea brine within the territory of Israel.

Cement to be exported

Israel should be producing enough cement by the spring of 1953 to satisfy not only her own requirements but also to permit about 250,000 tons of exports, officials of the Nesher Cement Works have stated. In 1951, Israel had to import 111,000 tons.

The Nesher Works now produce 460,000 tons of cement annually. By next year the new Nesher plant at Ramleh will be producing at an annual rate of 160,000 tons, while the Shimshon factory at Har Tuv, now under construction, will have a productive capacity of 250,000 tons.

Fertiliser plant progresses

An I£12,000,000 plant is now under construction in Haifa Bay on an 80-acre site adjoining the British-owned oil refineries. Some laboratories and plants are already operating. The entire project is scheduled for completion by 1954.

Fertilisers and Chemicals Ltd., the Israeli firm building the new plant, relies mainly on local raw materials. The company has developed a process for concentrating local rock phosphate to 66%, thus raising it to the quality of superphosphates. An American company is erecting ammonia and sulphuric acid plants which will enable the company to manufacture 8,000 tons of superphosphates monthly, while a Belgian company is supervising the erection of a nitric acid plant.

The necessary capital has been raised by various domestic and foreign loans and private capital from overseas. Imperial Chemical Industries Ltd. has invested I£437,000, making that company the second largest shareholder; the biggest is the Israeli Government.

CHILE

Penicillin factory to be built

Chile will produce all the penicillin it needs when a new plant built by the National Bacteriological Institute begins operations next year. The centre is being constructed by the Government with United Nations help.

Chile at present produces only 10% of her penicillin requirements.

UGANDA

Exploitation of phosphates and niobium

Representatives of several well-known mining and chemical groups, including Monsanto Chemicals Ltd., African Explosives and Chemicals Ltd., Rio Tinto Co. Ltd., Kilembe Mines Ltd., Frobishers Ltd. and various consultants, recently met in Entebbe to discuss with the Uganda Government and the Development Corporation the development of the country's mineral wealth. Niobium, phosphate and magnetite deposits near Torcro are being considered.

A syndicate will probably be formed for further exploration of the deposits. It is expected that an industry will be established producing phosphorus, superphosphates and fertilisers. Iron and steel manufacture may be started later, as adequate power will be available for the electric smelting of both phosphorus and iron when the Owen Falls hydroelectric plant comes into operation. Plans are also under consideration for the manufacture of sulphuric acid at Kilembe by the end of 1954.

TUNIS

Mineral output up

Output of most minerals during the first six months of this year increased in each case compared with the same period last year. Lead output was 17,688 tons (in 1951 16,197), zinc blende 3,084 tons (2,601), iron ore 443,895 tons (440,313) and lime phosphate 1,174,000 tons (56% more than last year). Most of these minerals were exported, mainly to European countries. Britain received over 279,700 tons of iron ore and 125,470 tons of lime phosphates during the first six months of this year.

In the same period the Société de l'Hyper-Phosphate Reno exported 47,000 tons of superphosphates, of which 16,000 tons went to Brazil.

Salt exports amount to 48,000 tons, compared with 65,000 tons for the same period.

JAPAN

New nickel plant planned

Plans are being worked out jointly by the Newmont Mining Corpn. and the Nihon Yakin Kogyo K.K. (Japan Metallurgical Works) for construction of a pilot plant in Japan. The plant would produce nickel on behalf of the American company, according to Teijiro Ishikawa, director of the Nihon Yakin Kogyo K.K. The plans were first broached late last year, when a representative of Newmont Mining visited Japan to inspect nickel production installations, Mr. Ishikawa said. A basic agreement to develop the plans was reached in May.

According to Mr. Ishikawa, Newmont have agreed to loan $2,000,000 to the Nihon Yakin Kogyo K.K. for building the plant, on condition that all the nickel matte produced will be supplied to the new smelting works the American company has built at Vancouver.

Newmont are now preparing a design for the pilot plant to be built in Japan and, when it is ready, will send technicians to Japan for further discussion of details with the Nihon Yakin Kogyo K.K., Mr. Ishikawa said. The plant would be capable of handling 250 tons of nickel ore daily. Mr. Ishikawa declared that the American company was interested in the technique the Japanese company developed during the war and also by the fact that the Nihon Yakin Kogyo K.K. has a contract with Le Nickel, a French company, for supplies of nickel ore from New Caledonia. The plant would initially be of pilot-plant size, as the production technique was experimental.

The Japanese company has contracted to import 150,000 tons of nickel ore from New Caledonia annually, and hope that Newmont Mining, which holds shares of Le Nickel, would persuade the French company to supply more nickel ore to the Japanese company.

Domestic prices of nickel in Japan are very high, compared with those in the U.S.A., but by the use of this new technique it is claimed that nickel matte can be produced at a very low price.

AUSTRALIA

Sulphuric plant being built

Preliminary work is beginning on the construction of a £2,000,000 sulphuric acid plant at Port Adelaide, according to Mr. H. W. Lyons, managing director of Cresco Fertilisers Ltd. The new company, Sulphuric Acid Ltd., is expected to take over the completed plant by 1954.

PARAGUAY

Oil extraction plant wanted

The Commercial Department of the British Embassy at Ascuncion has received an enquiry from the firm Balcasa S.A., Pte. Franco 380, Ascuncion, for machinery for setting up a factory for extracting oil from coconuts, peanuts, sunflower seeds and castor seeds. Balcasa S.A. are reported to be importers on a large scale, handling as their main lines heavy and medium industrial plant and machinery, agricultural implements of all types, electrical equipment for industrial plants, etc. They are reported to have large modern showrooms.

It is suggested that any U.K. firms able to supply suitable equipment should send full particulars of their machines with trade literature, delivery dates and prices direct to the enquirers at the above address.

Further information can be obtained from the Commercial Relations and Exports Department of the Board of Trade, London.

UNITED STATES

Titanium output to be tripled

An agreement with Du Pont de Nemours to triple the company's output of titanium over the next five years has been signed by the Defence Materials Procurement Agency. Announcing the agreement, the Agency said the Government would advance Du Pont up to $14,700,000 to aid in expanding the company's titanium facilities at Newport and Edge Moor, Delaware. The loan is to be paid back with interest in the form of saleable titanium sponge. The production target is some 13,500 short tons during the five-year period.

The agreement with Du Pont is similar to one which the Government has with the Titanium Metals Corpn. of America, at Henderson, Nevada, providing for the production of 18,000 tons of titanium sponge over a five-year period.

Trioxane, new solid fuel

The Celanese Corpn. of America has begun large-scale production of trioxane, a solid fuel for heating field rations of military forces. The product is said to have been standardised by the U.S. Quartermaster Corps as the best solid fuel available for heating field rations. The company's capacity for trioxane is in excess of current military requirements and commercial quantities will be available for development work in the civilian field.

$6,500,000 for synthetic rubber research

The U.S. Reconstruction Finance Corporation has approved a $6,500,000 research and development programme on synthetic rubber for the year ending June 30, 1953, according to the R.F.C. Administrator, Mr. H. McDonald.

The Agency said this programme was a continuation of work that had been carried on in the past to maintain a technologically advanced and rapidly expandable domestic rubber-producing industry adequate for national defence and essential civilian requirements. Emphasis would be placed on improving the quality of cold rubber latex and on improved synthetic rubber for special purposes.

New phosphate plant planned

A phosphate fertiliser plant is to be erected near Salt Lake City as the result of an agreement between the Stauffer Chemical Co., American Smelting and Refining Co. and the Kennecott Copper Corp. Construction of the plant, which will have a capacity of some 60,000 tons yearly of concentrated phosphates, will begin soon and operations will start next summer. A joint company will be formed, the Stauffer Chemical Co. disclosed, with a capital of $4,000,000 to $5,000,000.

In addition to phosphate fertilisers, the plant will produce phosphoric acid by the wet process.

CANADA

Steel shortage slows sulphur programme

Only 25 to 40% of the additional sulphur tonnage originally expected this year from new Canadian sources is now likely to become available. Chief reason for the disappointing results in the expansion programme is the shortage of special stainless and of structural steel. Pulp and paper producers have been unable to get delivery of all the new equipment they have ordered for new pyrites roasting plants, six of which are at present under construction.

The new liquid sulphur dioxide plant being built at Copper Cliff, Ontario, by Canadian Industries Ltd. is expected to get under way on schedule in mid-October, despite the shortage of special stainless steel for the tanks in the tank cars. It will produce 90,000 tons of liquid SO_2 annually. Two sulphur recovery plants processing natural gas, in Alberta, have started production since the beginning of this year. One belongs to Shell Oil of Canada and the other to the Royalite Oil Co. Each has a rated capacity of 10,000 tons sulphur p.a.

$7,000,000 refinery modernisation

The contract for the major portion of a $7,000,000 modernisation programme at Imperial Oil's Regina refinery has been awarded to the Fluor Corpn. of Los Angeles. Fluor Corpn. intends to sub-contract a considerable portion of the work to western Canadian firms. Most of the construction workers will be recruited in the Regina area. Plant construction is expected to begin late this year and be completed by the spring of 1954. Clearing and preparation of the site has started.

BRAZIL

Second aluminium mill ready soon

Brazil's second aluminium mill, being built near Sao Paulo by the Companhia Brazileira de Aluminio, is expected to start operations by the end of this year. The factory, in which 1,000,000,000 cruzeiros have been invested, is planned to produce 7,000 tons p.a. of aluminium.

English, Danish, Swiss, Belgian, Italian, German, Canadian, Swedish and U.S. equipment has been supplied for the factory. About a quarter of the material used in its building is of Brazilian origin.

German photo chemicals plant

Approval has been given by the Industrial Development Commission for the transference of a German photographic materials plant to Brazil. It is said that 15,000,000 cruzeiros in Brazilian capital are to be invested in this enterprise.

Cellulose plant to be set up

A plant for the production of 40,000 tons p.a. of cellulose for the textile industry is to be built in Sao Paulo. It will be operated by an affiliate of Snia Viscosa, an Italian chemical and textile company.

Cement industry expands

Figures released for cement consumption during 1951 show that local production was able to meet some 2,100,000 tons of the demand as against imports of 650,000 tons. Although the local industry is expanding fairly rapidly, it is not expected that output will be in a position to meet all requirements for some time to come.

MEETINGS

Incorporated Plant Engineers

September 11. 'Liquid Fuel Firing,' by A. Moore, 7.30 p.m., Roadway House, Oxford Street, Newcastle-on-Tyne.

September 15. 'Amenities in Industry,' by H. S. Crump, 7.15 p.m., Radiant House, Bold Street, Liverpool.

September 16. 'Mechanical Handling Equipment and Methods,' by F. T. Dean, 7 p.m., Engineering Centre, Sauciehall Street, Glasgow.

September 16. 'Heat Transfer from Steam,' by R. A. Brecknell, 7 p.m., 25 Charlotte Street, Edinburgh.

September 17. 'Energy from the Atom,' by A. F. Possnett, 7.15 p.m., Grand Hotel, Bristol.

September 25. 'Hazards and Regulations in Steelworks,' by a factory inspector, 7.30 p.m., Grand Hotel, Sheffield.

September 26. 'Modern Factory Lighting,' by F. Jamieson, 7.30 p.m., Imperial Hotel, Birmingham.

Institute of Metal Finishing

September 15. 'Rhodium Plating and its Modern Applications,' by E. H. Laister and R. R. Benham, 6 p.m., Northampton Polytechnic, St. John Street, London, E.C.1.

October 7. 'Bright Copper Plating with Periodic Reversal,' by F. Wild, 6.30 p.m., James Watt Institute, Great Charles Street, Birmingham 3.

Institution of Mining and Metallurgy

September 23-24. Symposium, 'Mineral Dressing,' Salisbury House, Finsbury Circus, London, E.C.2.

Institution of the Rubber Industry

September 28. Symposium, 'Modern Methods of Studying Rubber Properties,' Institution of Electrical Engineers, Savoy Place, London, W.C.2.

International Conferences

September 8-11. Exhibition and Joint Conference of the Industrial Instruments and Regulators Division, American Society of Mechanical Engineers, and the Instrument Society of America, Cleveland, Ohio, U.S.A.

September 10-12. Fiftieth Annual Meeting, National Petroleum Association, Atlantic City, New Jersey, U.S.A.

September 11-15. General Assembly, Society of German Metal Smelters and Miners, Freiberg.

September 14-19. National Meeting, American Chemical Society, Atlantic City, New Jersey.

September 15-20. International Symposium on Chemistry of Cement, organised by Building Research Station, Department of Scientific and Industrial Research, London.

September 22-24. Annual Meeting, American Coke and Chemicals Institute, White Sulphur Springs, W. Virginia.

September 22-24. Petroleum Mechanical Engineering Conference, American Society of Mechanical Engineers, Kansas City.

September 22-30. Conference and Exhibition, 'Instruments and Measurements,' Royal Swedish Academy of Engineering Sciences and the Association of Technical Physicists, Stockholm.

September 27-*October* 4. Fourth International Congress of Industrial Heat and Applied Thermodynamics, Paris.

October 1-5. 'Standardisation of Test Methods in the Field of Rubber,' International Standards Organisation Committee (ISO/TC/45) Meeting, Balliol College, Oxford, England.

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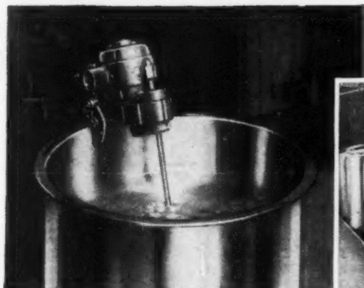
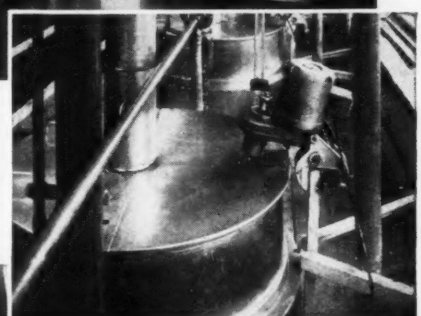
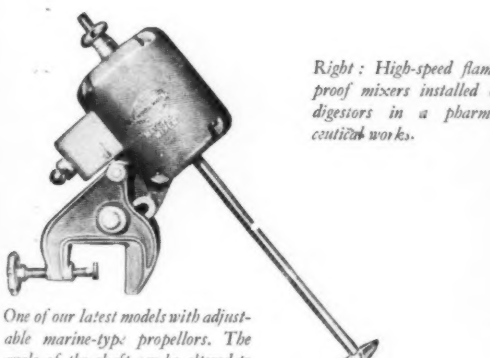


Above: Medium speed portable stirrer for agitating light oils or semi-viscous liquors.

Right: Battery of slow speed WGA Mixers installed on syrup tanks in a leading soft drinks factory.



Right: Battery of medium speed fluid mixers installed on sauce production at a well-known foodstuffs factory.



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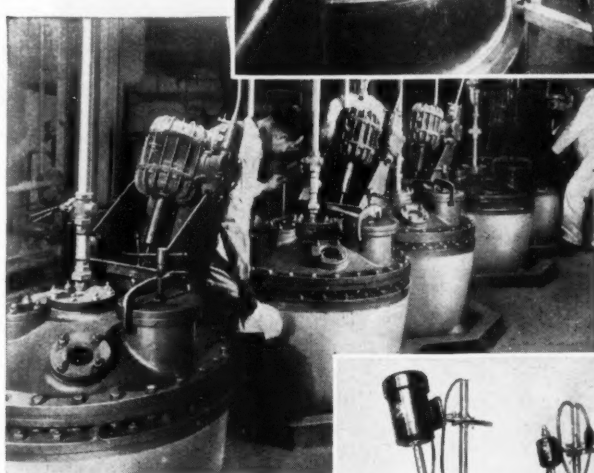
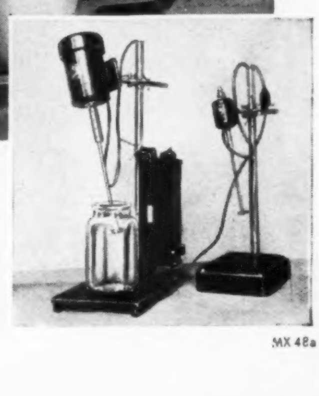


Right: High-speed flame-proof mixers installed on digestors in a pharmaceutical works.



Right: 1/60 H.P. and 1/8 H.P. laboratory type mixers for experimental purposes.

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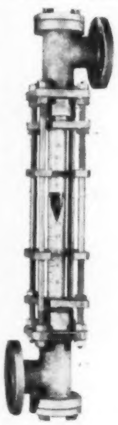

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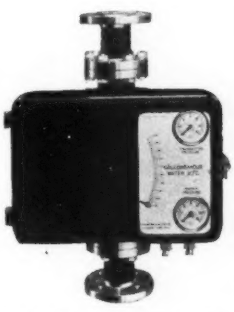

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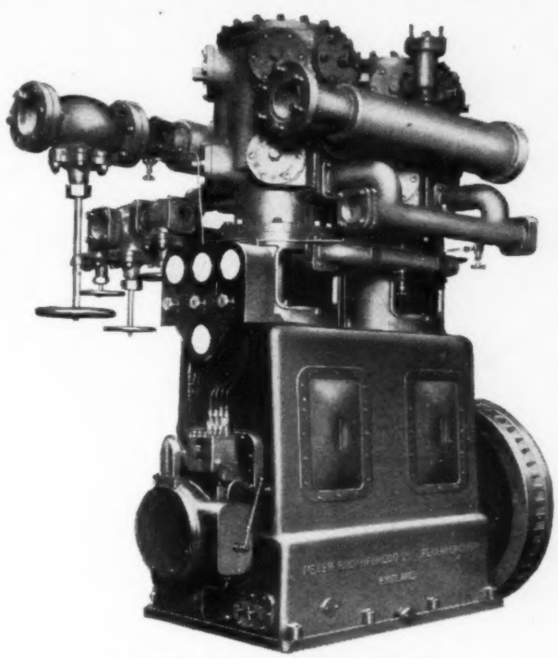

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